POWER

Volume 54 New York, August 23, 1921 *Number* 8

Not to Be Leaned Upon

UNITED STATES Senator James A. Reed, after withholding his speech in opposition to the Frelinghuysen coal measures for a month and carefully editing it, permits its publication to a Waiting World.

And the Waiting World got just what it might have expected to get from United States Senator James. A. Reed.

He lays the high price of coal to high labor and transportation charges, but he does not tell how much the labor of getting out a ton of coal costs. And the producers will not tell either. It was one of the purposes of such bills as Senator Reed was opposing to make them tell. But if the coal producers could be made to own up to their costs, so could the purveyors of food products, shoes, clothing and other necessities of life, and there would be a reign of "Socialistic Madness."

He says that it would take six thousand years at the present rate of consumption to exhaust the known supply of bituminous coal. But the rate of consumption is increasing by leaps and bounds. In the aeons in which the world's history is measured the steam engine is a new invention. We have only recently celebrated the first centenary of the death of its inventor, and the age of giant industries which it has created is only now fairly established.

"Bituminous coal," says the Senator, "is the one thing that for all practical purposes may be said to be inexhaustible" and when the mines give out "humanity will probably have advanced to a point far beyond the crude processes of producing heat by burning coal."

Milk! Milk, my friends, while the milking is good. The industries and public utilities and private consumers that depend upon coal for their existence will stand still and give down, and if they get restless we are here to hold them.

Wanting to know what it costs you to deal out *your* coal to them, and how much you are making out of the service which you are rendering them! "Socialistic Madness!"

The supply of fuel left to us from the carboniferous age is *not* inexhaustible Already we have seen the depletion of natural gas, the overtaking of the available petroleum supply by the growing demand upon it and the limit of the anthracite deposits. Already the struggle for the fuel supply has commenced. Witness the Saar Valley, Silesia, and Mexico. The most threatening cause of future warfare will be the covetousness or necessity to control these resources of energy upon which the industries, the well being, the existence itself of nations will depend.

The extravagance-inviting attitude of United States Senator James A. Reed is to be deprecated. It is time even now to visualize the day when the diminishing inhabitants of this cooling sphere will be clinched in a life-and-death struggle for its few remaining heat units.

F. R. Low

Power Plant Designed To Meet Conditions in Coal-Mining District

Plant Designed for 100,000 Kw.—40,000 Kw. Installed in Two 20,000-Kw. Units—Twin Jet Condensers Used—Boilers Contain 16,000 Sq.Ft. of Heating Surface Each—Control of Boiler Operation Is Automatic —Heat Balance Worked Out in Detail

By W. P. GAVIT
Mechanical Engineer, Dwight P. Robinson and Company, Inc., New York City

ANOTHER instance of transmitting power from the mine mouth for use over an extended territory is the Seward Power Station of the Penn Public Service Corporation. The transmission system of this company covers parts of Cambria, Center, Clearfield, Indiana, Somerset and Westmoreland Counties in Pennsylvania and serves an area approximating 2,500 square miles. This system consists of 459 miles of 22,000-volt, 19 miles of 66,000-volt steel-tower lines and the necessary distribution and service lines. Previously to the construction of the plant at Seward, this company operated two plants in Johnstown, one in Philipsburg and one in Rockwood.

In 1911-12 surveys and estimates were made to determine the probable growth of business in the territory served by the Penn Public Service Corp., which showed that the facilities then existing for power production could not be economically developed to supply the future demand. The controlling factor in the choice of location for a steam-power plant is an adequate supply of water for condensing purposes. After a careful survey of the available sites for a power station, Seward was chosen as being the best in point of fuel supply, water supply for condensing purposes and geographical relation to the distribution system. The flow records of the Conemaugh River indicated that there was sufficient water in the river at minimum flow to handle approximately 60,000 kw. The fact was also developed that with a dam, water storage sufficient for the condensing requirements of 100,000 kw. could be made available. A coal mine owned by an affiliated company is situated within 600 ft. of the power station. This mine is capable of future development for a production of 1,000 tons daily.

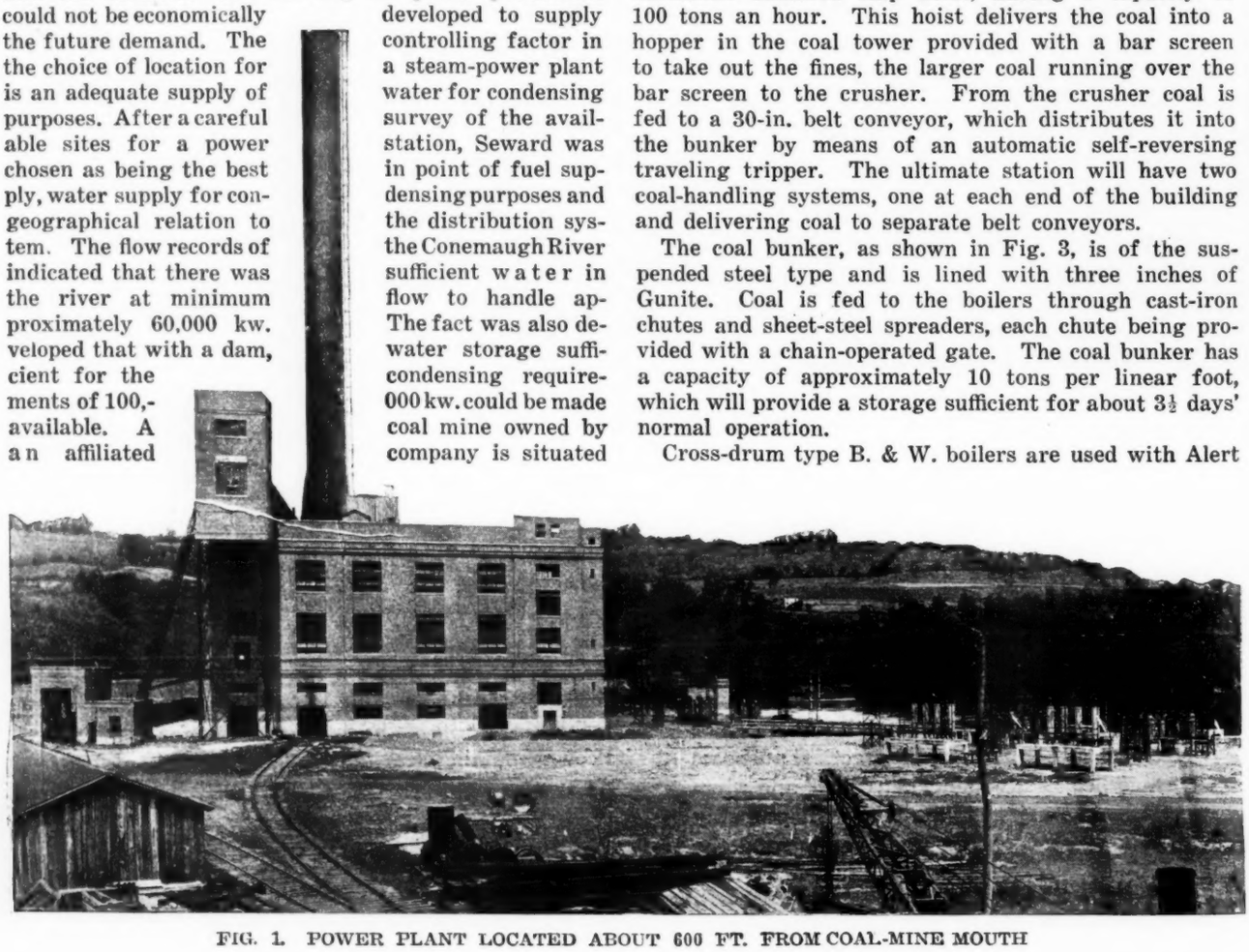


FIG. 1. POWER PLANT LOCATED ABOUT 600 FT. FROM COAL-MINE MOUTH

The building is of brick and steel with concrete foundations. As shown in the cross-section, Fig. 6, the boiler-room basement floor is at elevation 1,085, practically level with the surrounding ground level, and the turbine-room basement-floor level is 8 ft. lower. This difference in level was necessary to facilitate the pumping of condensing water, the lowest water level in the river being 1,070 and the height of the condenser injection nozzles being some 16 ft. above the floor level. This makes a total static head of 23 ft. All floors in the building are reinforced concrete and are finished rough to prevent slipping.

The coal-handling system consists of a double semi-automatic balanced skip hoist, having a capacity of 100 tons an hour. This hoist delivers the coal into a hopper in the coal tower provided with a bar screen to take out the fines, the larger coal running over the bar screen to the crusher. From the crusher coal is fed to a 30-in. belt conveyor, which distributes it into the bunker by means of an automatic self-reversing traveling tripper. The ultimate station will have two coal-handling systems, one at each end of the building and delivering coal to separate belt conveyors.

The coal bunker, as shown in Fig. 3, is of the suspended steel type and is lined with three inches of Gunite. Coal is fed to the boilers through cast-iron chutes and sheet-steel spreaders, each chute being provided with a chain-operated gate. The coal bunker has a capacity of approximately 10 tons per linear foot, which will provide a storage sufficient for about 3½ days' normal operation.

Cross-drum type B. & W. boilers are used with Alert

baffling, and have 16,000 sq.ft. of heating surface each. The present installation comprises three boilers, the ultimate station being designed for sixteen. Each boiler is 18 tubes high by 39 wide and has a 60-in. drum. The bottom of the tube headers at the lower end are 15 ft. and the drum centers, 35 ft. above the boiler-room floor. Each boiler is equipped with a Foster superheater having 5,000 sq.ft. of heating surface. These superheaters are designed to raise the temperature of the steam 180 deg. F. above the saturated-steam temperature when the boilers are operating at 200 per cent rating.

Settings for the boiler are entirely of firebrick. Outside the firebrick is placed a layer of 4-in. Sil-o-Cell brick, next to this ¼-in. asbestos millboard, and outside of this a steel casing. As shown in Fig. 5, a row of steam nozzles is provided at *X* along the side tuyeres and along the back wall just over the clinker grinder. The nozzles are of cast iron and have a ⅛-in. slot for the steam, Fig. 5. They are provided with four longitudinal grooves, and the rear end is castellated to permit a flow of air about them. It is expected that this air flow will effectually prevent their burning. These nozzles are fed with steam from the saturated-steam drum, the piping being so proportioned that the pressure at the nozzle is very low. The steam rising from these nozzles is intended to prevent the formation of clinkers on the furnace wall.

Taylor stokers of the underfeed type are used, consisting of 13 extra-long retorts per boiler. Each stoker is equipped with a double-roll clinker grinder which delivers the ash into a large hopper directly beneath the grinder and separated from the boiler-room steel structure. The stoker and clinker-grinder speeds are controlled by hand from the boiler-instrument board shown in Fig. 3. The ash hoppers are each provided with three 5- x 5-ft. air-operated gates by means of which the ash may be dumped directly into standard railway cars which run on standard-gage tracks located in the boiler-room basement.

The forced-draft system consists at present of two 250,000-cu.ft. per min. fans designed to deliver air against a static pressure of 6 in. of water, and are driven by 375-hp. Westinghouse turbines through a reduction gear. The fans are in housing in the auxiliary bay with the fan shafts protruding through the wall so that the turbine and gears are in the auxiliary bay where the other auxiliary equipment is located. Air from the fans is delivered into a main forced-draft duct which runs longitudinally through the boiler room under the firing aisle. Each stoker is supplied with air through four small draft ducts.

Draft control for these boilers is automatic. The main uptake dampers are all connected to a common shaft, their position being controlled by a Hagan regulator which is actuated by variations of steam pressure in the main high-pressure steam header. This arrangement will tend to give uniform operation on all boilers. In order to compensate for variations between the fire conditions in the individual furnaces, the supply of forced draft is separately controlled for each boiler. Another regulator is balanced between atmospheric pressure and the pressure over the fire. In case of a fall in steam pressure all uptake dampers will be opened by the master regulator previously mentioned. This will cause a fall of pressure over all fires. The individual regulators will then open dampers which are provided in the small ducts between the main forced-draft duct and the stokers, sufficient to bring the pressure over the fire back to the point for which the regulators are set. Then if any one fire develops holes or other conditions different from the rest of the fires, these individual regulators will properly handle the draft supply for each fire. It is believed that this

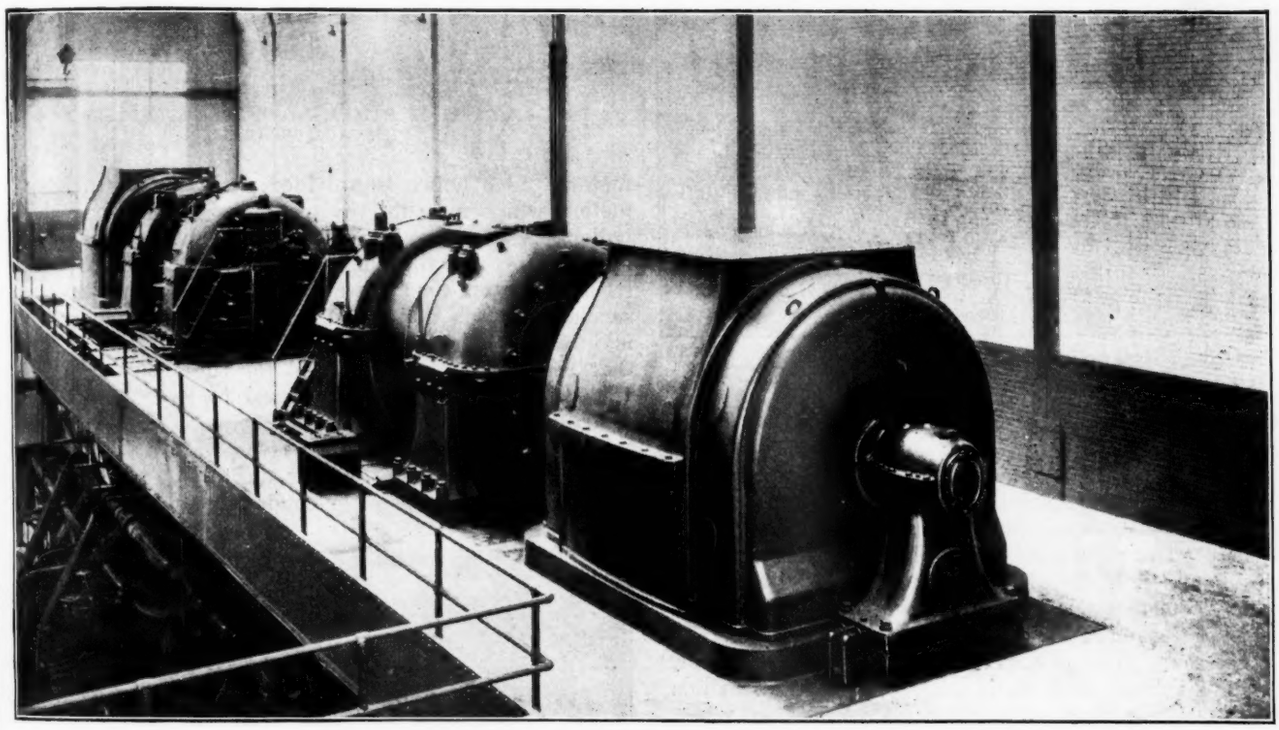


FIG. 2. TWO 20,000-KW. TURBO-GENERATORS INSTALLED

system of regulation will tend to keep all boilers operating at the same rating, at the same time correcting for any differences in the conditions in individual boilers. In addition to the controls referred to, each fan is provided with a Hagan control actuated by vari-

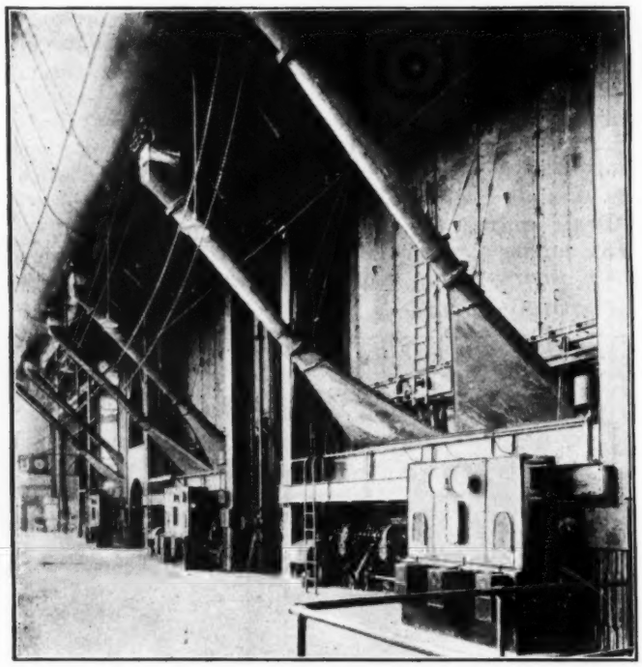


FIG. 3. THREE 16,000-SQ.FT. BOILERS INSTALLED

ations of the steam pressure in the main high-pressure steam header.

Water in the Conemaugh River contains a considerable quantity of free sulphuric acid, and for this reason it was not considered practicable to use surface condensers. The main generating units are Westinghouse, semi-double flow, rated at 20,000 kw. at 80 per cent power factor. Each turbine is provided with a twin low-level jet condenser of the Le Blanc type. The turbine-room floor is 35 ft. above the basement floor, making it necessary to insert between the turbine exhaust nozzle and the condensers, extension pipes. The turbine exhaust nozzle is connected to these extension pipes by two water-cooled rubber expansion joints of the same type as were used in the Colfax Station of the Duquesne Light Co., which were described in the issues of April 5 and May 3. The air pumps are of the Westinghouse steam-ejector type. There are seven ejectors for each twin condenser, five of them being sufficient for the removal of air under full load; that is, when the turbine is passing 240,000 lb. of steam per hour.

Arrangement of the feed and service-water system in this station is of interest. Fig. 7 is a single-line diagram of this system. Water may be fed to the service pumps either from the condensing-water discharge tunnel or from the water supply that comes from Hices Run, a stream in the hills near the station. Water from this stream is excellent for boiler purposes. From the service pumps, two 10-in. service lines are carried up to two 10,000-gal. head tanks on the boiler-room roof. Taps for the supply of the various services in the station are taken from these two lines and provided with valves so that water may be taken from either line. The transformer-cooling water, after passing through the transformers, is carried across the turbine-room basement floor into two tanks beneath the floor. From these tanks the water is pumped to the air-ejector condensers, which are described later. The water leaving the air-ejector condensers is pumped into the line that feeds the water-treating system. From the water-treating system the boiler water runs down through the filters into the boiler-feed tank from which the boiler-feed pumps take their suction. Water drawn from the boiler-feed tank is measured by a V-notch

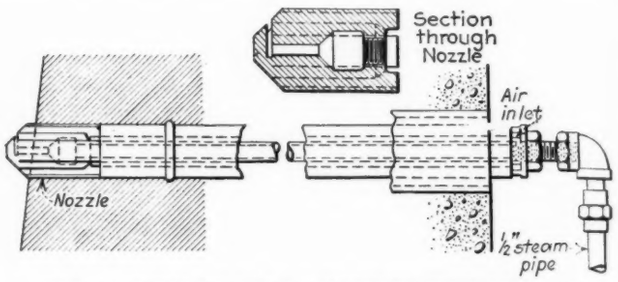


FIG. 4. TYPE OF STEAM NOZZLES INSTALLED IN FURNACE WALLS

meter. Each boiler is provided with two venturi-type meters which measure the water fed to the individual boiler. A considerable quantity of water is required for flushing out the sludge lines from the feed-water treating system for ash wetting and other miscellaneous services that do not require specially clean water. It is intended, when the water from Hices Run is low, that river water shall be used for these purposes. In view of this fact one of the head tanks is lined with concrete to prevent excessive corrosion due to high sulphuric-acid content of the river water.

The discharge from the air ejector is carried in a 10-in. line to the air-ejector condenser shown in Fig. 9.

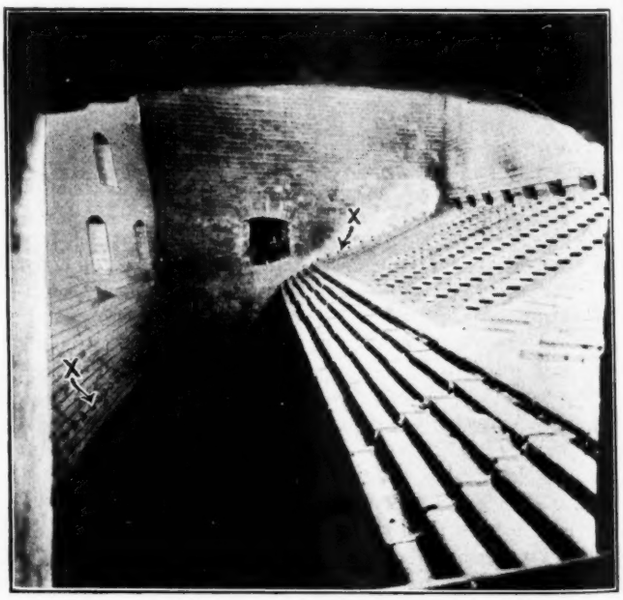


FIG. 5. INSIDE ONE OF THE BOILER FURNACES

In the upper part of the main tank are two smaller tanks into which the steam and air enter through a pipe perforated on its lower side. Directly below this pipe is a 6-in. pipe perforated on its upper side, through

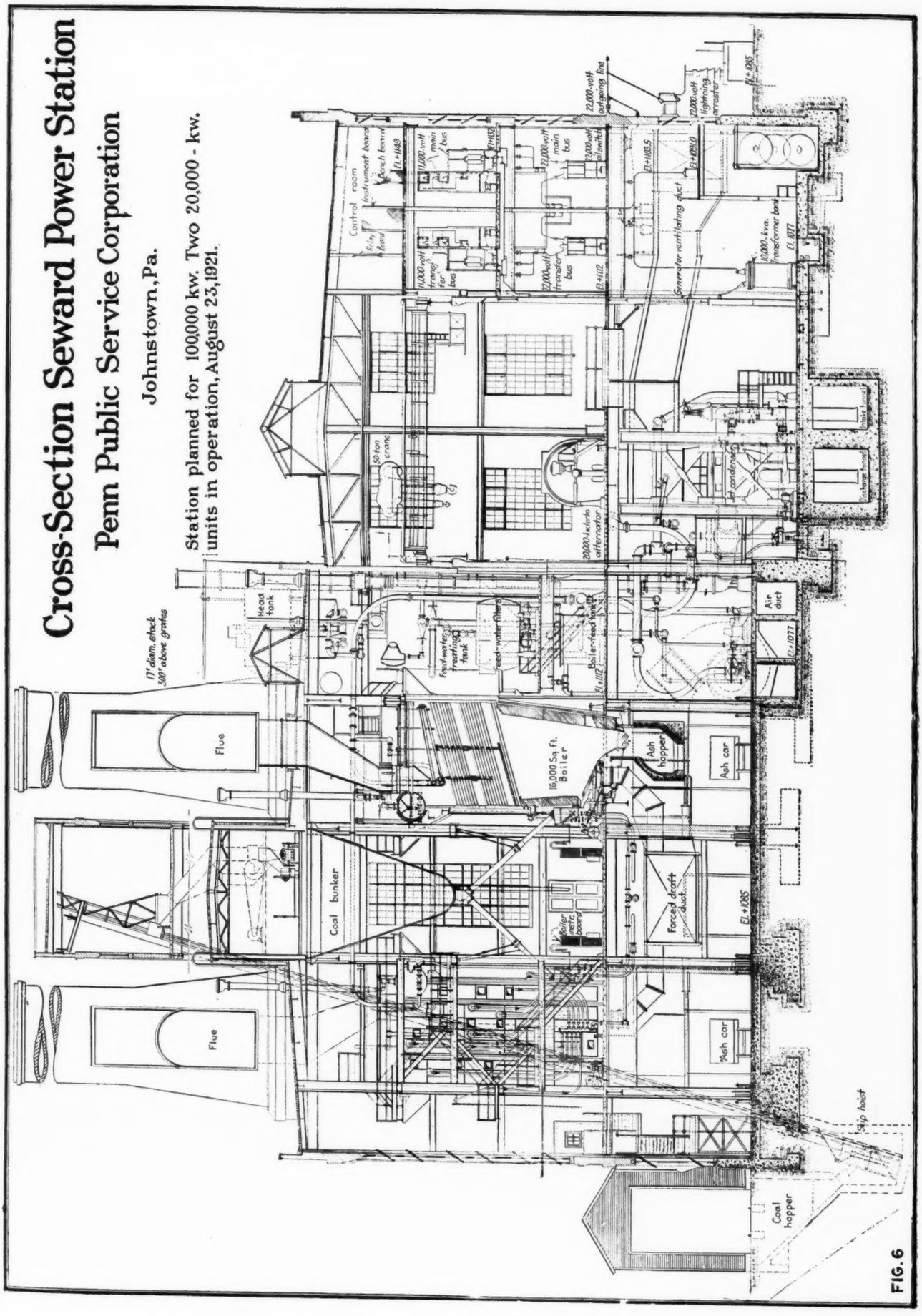

Cross-Section Seward Power Station
Penn Public Service Corporation
Johnstown, Pa.
Station planned for 100,000 kw. Two 20,000 - kw. units in operation, August 23, 1921.
17' diam. stack 300' above grates
Head tank
Feed-water heating tank
Feed-water filters
Boiler-feed tanks
Flue
Flue
Coal bunker
16,000 Sq. ft. Boiler
Ash hopper
Ash car
Ash car
Forced draft duct
Air duct
Boiler instr. board
Control room
Instrument board
Bench board
Relay Panel
50-ton crane
11,000-volt transfer bus
11,000-volt main bus
22,000-volt transfer bus
22,000-volt main bus
22,000-volt oil switch
22,000-volt outgoing line
22,000-volt lightning arrester
Generator ventilating duct
10,000-kva. transformer bank
20,000-kv.-a. alternator
H2 condenser
Inlet tunnel
Discharge tunnel
Skip hoist
Coal hopper
El. 1085
El. 1077
El. 1102
El. 1112
El. 1148
El. 1165.5
El. 1191.0

FIG. 6

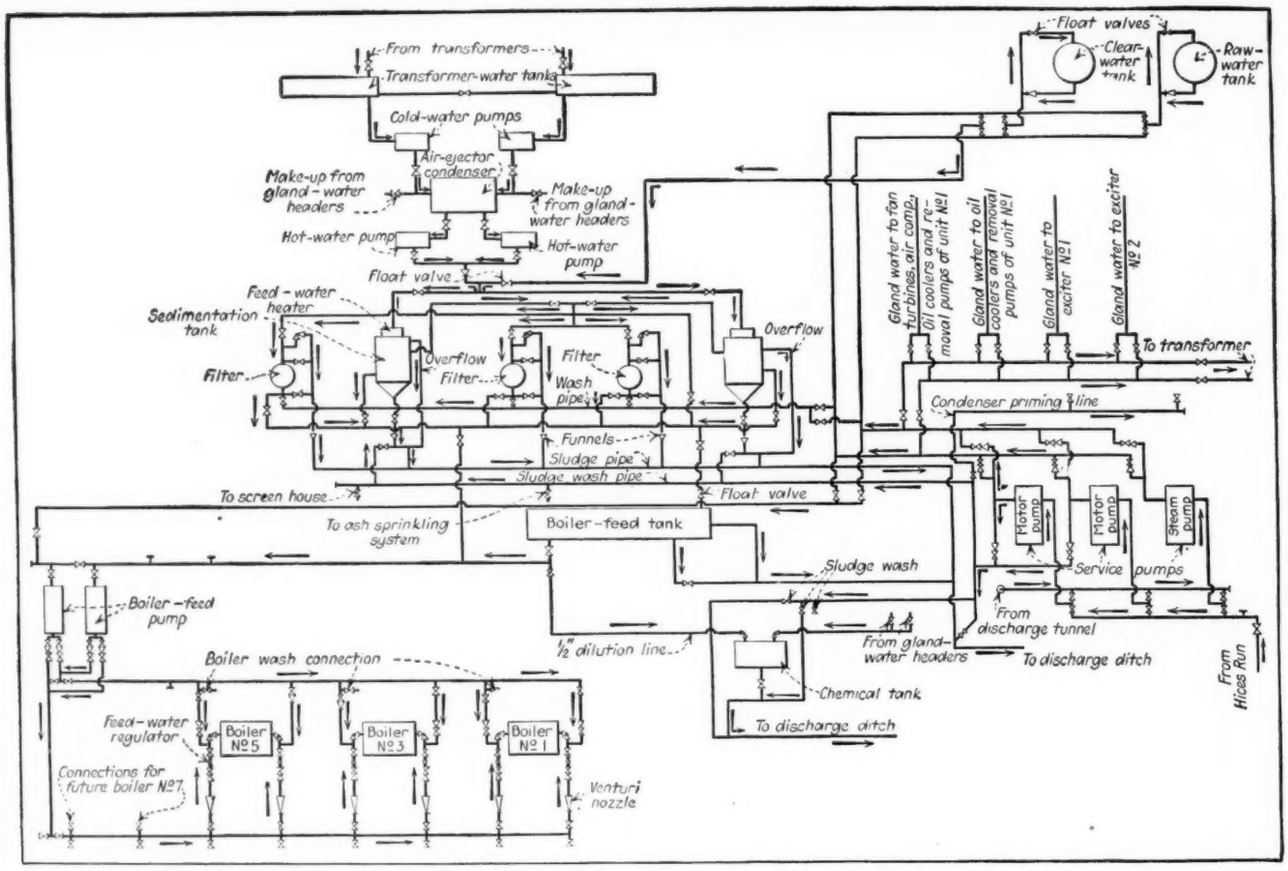


FIG. 7. FEED-WATER PIPING DIAGRAM

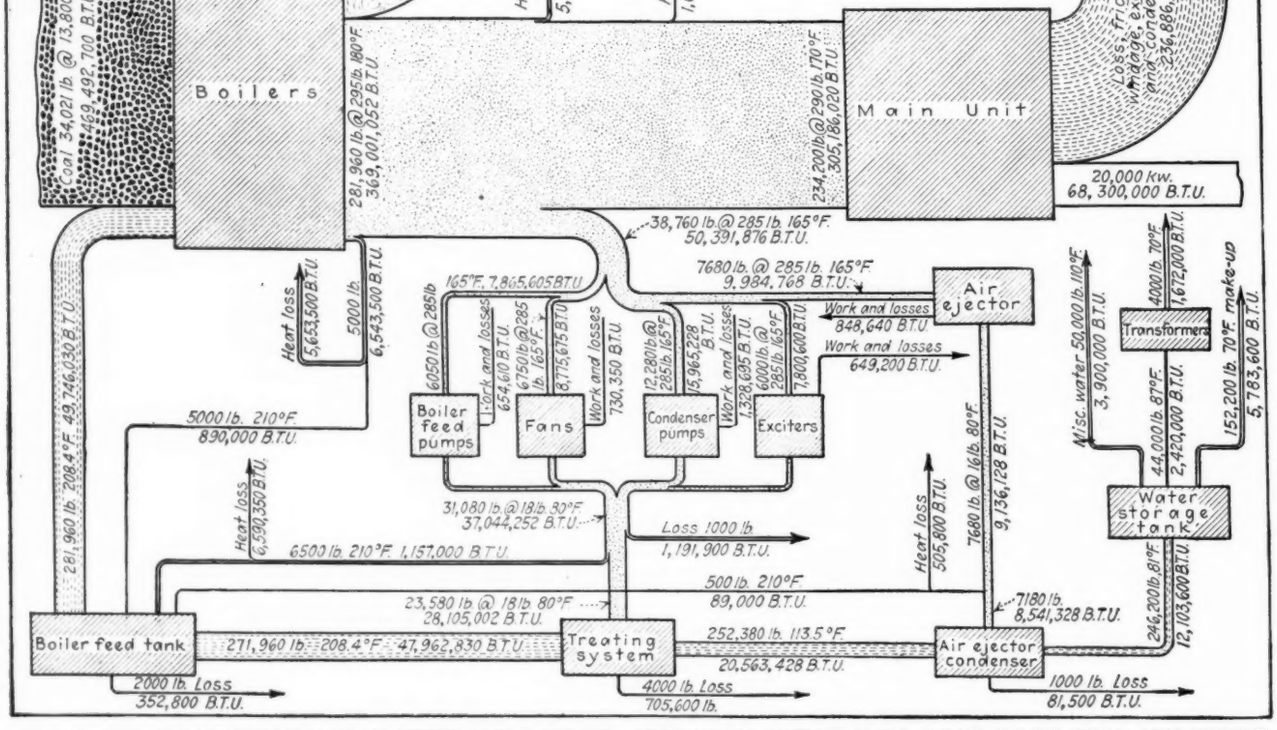

Note: All pressures given are absolute. Quantities are hourly
Losses; stack, radiation etc. 150,237,618 B.T.U.
H-P Steam lost 4000 lb. 5,234,800 B.T.U.
Heat loss 1,645,456 B.T.U.
Coal 34,021 lb. @ 13,800 B.T.U. 469,492,700 B.T.U.
Boilers
281,960 lb. @ 295 lb. 180°F. 369,001,052 B.T.U.
234,200 lb. @ 290 lb. 170°F. 305,186,020 B.T.U.
Main Unit
Loss, friction, windage, excitation and condenser 236,886,200 B.T.U.
20,000 Kw. 68,300,000 B.T.U.
38,760 lb. @ 285 lb. 165°F. 50,391,876 B.T.U.
7680 lb. @ 285 lb. 165°F. 9,984,768 B.T.U.
Air ejector
Work and losses 848,640 B.T.U.
Work and losses 649,200 B.T.U.
Heat loss 5,653,500 B.T.U.
5000 lb. 6,543,500 B.T.U.
165°F. 7,865,605 B.T.U.
6050 lb. @ 285 lb.
Work and losses 654,610 B.T.U.
67501b. @ 285 lb. 165°F.
8,775,675 B.T.U.
Work and losses 730,350 B.T.U.
12,280 lb. @ 285 lb. 165°F. 15,965,228 B.T.U.
Work and losses 1,328,695 B.T.U.
6000 lb. @ 285 lb. 165°F. 7,800,600 B.T.U.
Boiler feed pumps
Fans
Condenser pumps
Exciters
5000 lb. 210°F. 890,000 B.T.U.
Heat loss 6,530,350 B.T.U.
281,960 lb. 208.4°F. 49,746,030 B.T.U.
31,080 lb. @ 18 lb. 30°F. 37,044,252 B.T.U.
6500 lb. 210°F. 1,157,000 B.T.U.
Loss 1000 lb. 1,191,900 B.T.U.
500 lb. 210°F. 89,000 B.T.U.
23,580 lb. @ 18 lb. 80°F. 28,105,002 B.T.U.
Heat loss 505,800 B.T.U.
7680 lb. @ 16 lb. 80°F. 9,136,128 B.T.U.
7180 lb. 8,541,328 B.T.U.
Misc. water 50,000 lb. 110°F. 3,900,000 B.T.U.
4000 lb. 70°F. 1,672,000 B.T.U.
Transformers
44,000 lb. 87°F. 2,420,000 B.T.U.
152,200 lb. 70°F. make-up 5,783,600 B.T.U.
Water storage tank
246,200 lb. 81°F. 12,103,600 B.T.U.
Boiler feed tank
271,960 lb. 208.4°F. 47,962,830 B.T.U.
Treating system
252,380 lb. 113.5°F. 20,563,428 B.T.U.
Air ejector condenser
2000 lb. Loss 352,800 B.T.U.
4000 lb. Loss 705,600 lb.
1000 lb. Loss 81,500 B.T.U.

FIG. 8. HEAT-BALANCE DIAGRAM WITH ONE TURBINE OPERATING UNDER FULL LOAD (20,000 KW.) AND THREE BOILERS OPERATING AT 211 PER CENT RATING

which the condensing water enters. Baffle plates placed 8 in. from the steam-inlet pipe compel all the water to pass close to it, thus insuring an intimate mixture of the steam and water. The overflow plate is at a height to maintain 12-in. of water over the steam-inlet pipe.

On account of the use of jet condensers there is no condensate for boiler feed and all water must be heated from a comparatively low temperature. This creates a demand for a considerable quantity of exhaust steam. Partly on this account and also to secure operating reliability, steam-turbine drive was adopted for the forced-draft fans, boiler-feed pumps and condenser-removal pumps. The duplex drive on the exciters provides means for regulating the quantity of exhaust steam available to maintain the heat balance.

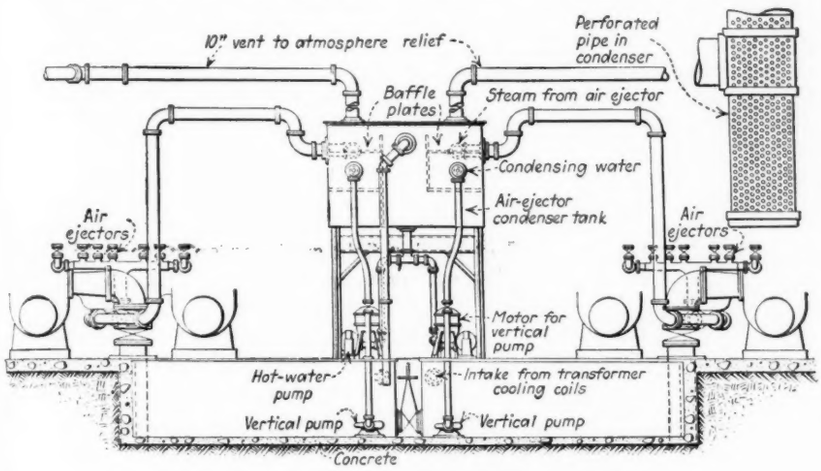


FIG. 9. AIR-EJECTOR CONDENSER SYSTEM

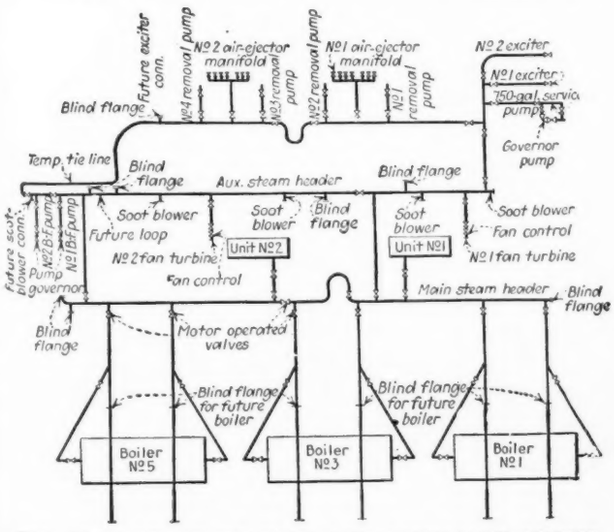


FIG. 10. LAYOUT OF MAIN AND AUXILIARY PIPING

Water coming into the station may in winter be but a few degrees from the freezing point. In the transformers its temperature will be raised from 15 to 17 deg. The air-ejector discharge will increase the temperature about 30 deg. more. The balance of the heat must be supplied in exhaust steam at the feed-water heaters located on top of the sedimentation tanks. Fig. 8 shows a heat balance worked out for the station, under a given set of conditions; namely, 20,000 kw. load on one turbine and three boilers on the system. Under this condition the turbine will be operating somewhat above its best water rate and the boilers at about 211 per cent rating.

On account of the possibility of having to use river water for boiler feed, a feed-water treating system of the Sorge Cochrane hot-process type guaranteed to treat 60,000 gal. per hour. was provided. This guarantee is based on the worst combination that is shown in any records of analysis of the Conemaugh River. The gland and bearing-water discharge and all steam drips are carried into the tanks beneath the turbine-room basement floor, thus conserving all heat absorbed by these waters.

The layout of the main steam piping is shown in Fig. 10. There are two leads from each boiler running through a Y-connection into 10-in. pipes to the main steam header. All pipe and fittings are of steel. High-pressure steam valves are of steel with monel-metal trimmings. Ample provision is made for expansion loops and large radius bends; $\frac{1}{16}$-in. ring gaskets are used in all flanged connections. The table is a pipe specification which shows the materials and types used in all piping throughout the station. All the main steam valves are electrically operated from a control board, Fig. 11, near the main turbines.

Water for the condensers is taken through a screen-house provided with two 7-ft. traveling screens. Water for flushing the screens is pumped from the intake tunnel directly behind the screens by a 300 gal. per min. motor-driven pump designed for a total discharge head of 190 ft. The discharge canal is carried out of the building directly to the river, but when the ultimate capacity is installed, this canal will be carried to a point some 2,000 ft. below the present outlet and just above a dam that will be constructed at that time. This will permit recirculation of condensing water at times when the flow of the river is unusually low.

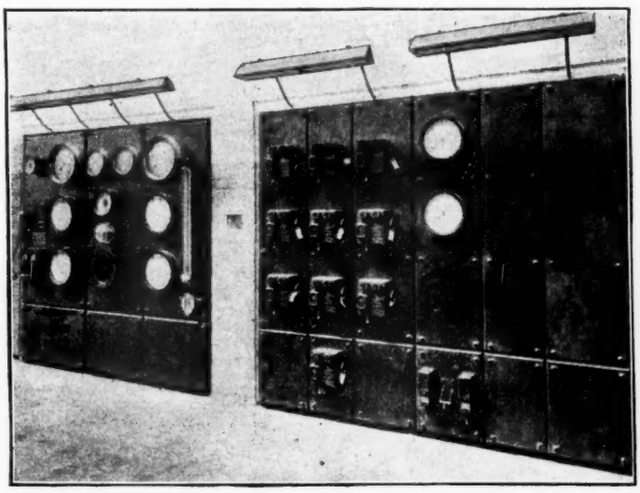


FIG. 11. CONTROL BOARD ON RIGHT, FROM WHICH ALL MAIN STEAM VALVES MAY BE ELECTRICALLY CONTROLLED

The generating equipment consists of two 25,000-kva. three-phase 60-cycle 11,000-volt turbo-generators, star-

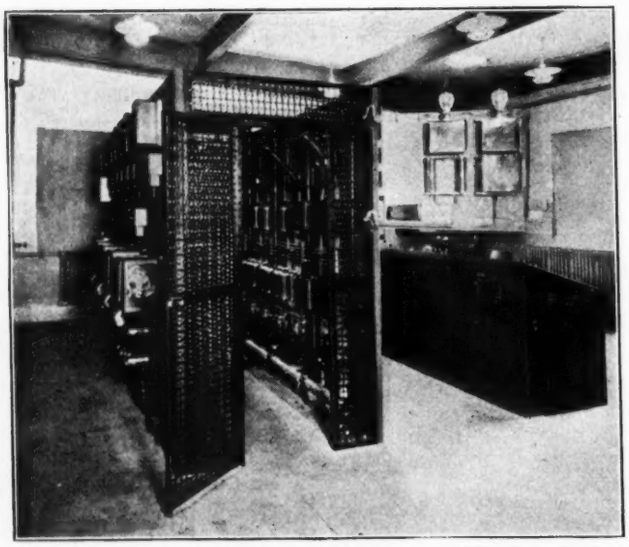


FIG. 12. VIEWS OF SWITCHBOARD IN CONTROL ROOM

connected, with neutral grounded through a 7-ohm resistor rated at 1,000 amperes for two minutes. Each machine's neutral is connected to a ground bus through an automatic oil circuit breaker, and this bus is connected to ground through the resistor, which is located in a fireproof compartment in the turbine-room basement. The neutral oil circuit breakers are interlocked so that only one machine can be grounded at a time, and if, from any unusual circumstance, the ground current should not be interrupted by the line switches in time to prevent overheating of the resistor, the neutral breakers will trip automatically before the resistor has burned out. Current transformers are provided for both the bus and ground leads from the generators, and their secondaries are connected to differential relays which trip both the generator line switches and generator field switches on voltage breakdown inside the generators.

Selector oil circuit breakers are used to connect the generators to duplicate 11,000-volt buses, located in busrooms which are entirely isolated from each other

PIPING AND FITTING SCHEDULE FOR MECHANICAL EQUIPMENT

Service	Pipe	Fittings	Valves	Gaskets	Flanges	Bolts
High - pressure main and auxiliary superheated steam. High - pressure drip system.	2-in. and under, E.S. steel. 2½-in. to 12-in., F.W. steel. 14-in. and over O.D., steel, ⅜-in. thick.	1½-in. and under, E.H. screwed F.S. 2-in. to 12-in., E.H. flanged C.S. 14-in. and over, E.H. flanged C.S. (special ports)	1-in. and under, E.H., F.S. and Monel threaded. 1½-in. to 1½-in., E.H., C.S. and Monel, O. S. & Y. threaded. 2-in. and over, E.H. flanged C.S. and Monel O.S. & Y. 6-in. and over, to be fitted with bypass.	Compressed asbestos 1/16 in. thick, such as Tradename.	2-in. to 4-in., E.H.F.S. welded to pipe. 5-in. and over, E.H.F.S. Van Stone.	Special oil-heat-treated with nuts on each end.
High - pressure saturated steam.	2-in. and under, E.S. steel. 2½-in. to 12-in., F.W. steel.	2-in. and under, E.H. screwed C.S. 2½-in. to 12-in., E.H. flanged C.S.	2-in. and under, E.H. screwed C.S. and Monel. 2½-in. and over, E.H., C.S. flanged & Monel (O.S. & Y. pattern). 6-in. and over, to be fitted with bypass.	Compressed asbestos 1/16 in. thick.	2½-in. to 5-in., E.H.F.S. welded to pipe. 6-in. and over, E.H.F.S. Van Stone.	Standard steel.
Feed - water lines.	3-in. and under, I.P.S. brass. 3½-in. and over, genuine wrought iron or E. S. steel.	2-in. and under, E.H. screwed cast iron. 2½-in. and over, E.H. flanged cast sem-steel.	2-in. and under, E.H. screwed pattern, all bronze. 2½-in. and over, E.H. flanged semi-steel and bronze (O.S. & Y. pattern)	Compressed asbestos 1/16 in. thick.	E.H. F.S. Van Stone for steel pipe.	Standard steel.
Boiler blowoff. Superheater blowoff.	2-in. and under, E.S. steel. 2½-in. and over, inside station, E.S. steel; outside station, E.H. flanged cast semi-steel.	2 - in. and under, E. S. screwed cast iron. 2-in. and over, E.H. flanged cast iron.	2 - in. and under, E.H. screwed cast-iron and bronze. 2½-in. and over, E.H. flanged cast-iron and bronze (O.S. and Y. pattern).	Compressed asbestos 1/16 in. thick.	E.H. steel for steel pipe. 2-in. to 4-in., welded, 4-in. and over, Van Stone. Cast integral for cast semi-steel pipe.	Standard steel.
Feed - suction piping. Low - pressure service piping. Hotwell piping. Circ. and misc. water.	2-in. and under, E.S. galv. steel. 2½-in. to 3-in., standard galv. steel. 4-in. and over, genuine wrought iron or E.S. steel or cast iron.	3½-in. and under, standard screwed cast iron. 4-in. and over, standard flanged cast iron.	2-in. and under, standard screwed composition (inside screw pattern). 2½-in. to 3½-in., standard screwed, cast iron and bronze. 4-in. and over, standard flanged cast iron and bronze (O.S. and Y. pattern).	Packing Tradename 1/16 in. thick.	Standard cast-iron threaded for wrought-iron or steel pipe. Cast integral for cast-iron pipe.	Standard steel.
Main and aux. exhaust. Vacuum lines. Compressed air. Low - pressure drips. Misc. low-pressure steam.	2-in. and under, E.S. steel. 2½-in. to 12-in., standard steel. 14-in. to 22-in. O.D., steel ⅜-in. thick. 24-in. and over, standard cast iron.	3½-in. and under, standard screwed cast iron. 4-in. and over, standard flanged cast iron.	2-in. and under, standard screwed composition (inside-screw pattern). 2½-in. to 3½-in., standard screwed cast iron and bronze. 4-in. and over, standard flanged cast iron and bronze. (O.S. and Y. pattern).	Packing Tradename 1/16 in. thick.	12-in. and under, standard cast iron. 14-in. to 22-in., standard Van Stone. 24-in. and over, cast integral.	Standard steel. In large flanges bolts ⅛ in. smaller than standard
Free exhaust.	12-in. and under, standard steel. 14-in. to 22-in. O.D., steel ⅜-in. thick. 24-in. and over, standard cast iron and vertical spiral riveted galv. steel.	Standard flanged cast iron.	Relief valves, cast iron and bronze. Water-sealed 18-in. and over, with hydraulic cylinders and remote control.	Packing Tradename 1/16 in. thick.	12-in. and under, standard cast iron. 14-in. to 22-in., standard Van Stone. 24-in. and over, cast integral. Vertical spiral riveted, standard cast -iron.	Standard steel. In large flanges bolts ⅛ in. smaller than standard.
Oil.	2-in. and under, E.S. steel. 2½-in. and over, standard steel.	3½-in. and under, standard screwed cast iron.	2½-in. and under, standard screwed composition. 4-in. and over, standard flanged cast iron and brass (inside-screw pattern).	Compressed asbestos.	2-in. to 4-in., F.S. welded.	Standard steel.

E.S., extra strong; E.H., extra heavy; F.S., forged steel; C.S., cast steel; I.P.S., iron-pipe size; F.W., full weight; O.D., outside diameter; O.S. & Y., outside screw and yoke. Unions to be "Tradename." All semi-steel material to be tested to 600 lb. All valves provided with removable seats and disks.

by a longitudinal fire wall. The station is designed for supplying the entire load at either 66,000 or 22,000 volts. The load from the two generators now installed is delivered through two three-phase 15,000-kva. 11,000 to 66,000-volt transformers and two three-phase 10,000-kva. 11,000 to 22,000-volt transformers, all of which are in the basement of the electrical bay, in fireproof compartments entirely isolated from each other and from other equipment. The transformer compartments are adjacent to the turbine-room basement and are separated from it by rolling steel doors.

The 22,000-volt transformers are connected to duplicate 22,000-volt buses located in the building, these two buses being separated by a longitudinal fire wall, thereby providing the same general arrangement as that for the 11,000-volt buses. All 66,000-volt equipment except the transformers is located outdoor.

All equipment that is to be continuously watched by the operator should be visible to him from one point in the switchboard room. In order to accomplish this and to make all equipment accessible for inspection and repair, the type of switchboard shown in Fig. 12 was adopted. The generators and transformers are controlled from a bench section, and the feeders are controlled from a vertical section at right angles to it. Behind the bench section is a vertical section containing the instruments and other equipment to be continuously watched by the operator. Behind this vertical section is another vertical section, on which are mounted the relays, watt-hour meters, curve-drawing meters, etc. The two vertical sections are located back to back with grillwork across the ends of the board, thus completely housing the equipment on the backs of the panels. This design of switchboard permits a minimum length of board and still provides a large amount of space for locating the equipment that is mounted back of the panels, and the backs of switchboards are well protected.

The Seward Station was designed and constructed by Dwight P. Robinson & Co., Inc., New York City, under the direction of the officers of the Penn Public Service Corporation.

DATA ON PRINCIPAL EQUIPMENT IN SEWARD POWER STATION OF THE PENN PUBLIC SERVICE CORPORATION

GENERAL

Plant location	Seward, Pa.
Capacity, ultimate	100,000 kw.
Capacity installed, two 20,000-kw. units	40,000 kw.
Boilers installed (16,000 sq.ft. each)	3
Boilers installed, ultimate (16,000 sq.ft.each)	16

Auxiliaries and other drives:
Forced-draft fans, boiler-feed pumps, circulating pumps, and one service pump; turbine driven.

Exciters:
Duplex drive (turbine and motor).
All other drives motor.

Nature of load served:
Mostly mining and steel mills.

Length of turbine room, inside (ultimate)	325 ft.
Width of turbine room, inside	50 ft.
Width of electrical bay	32 ft.
Length of boiler room inside (ultimate)	360 ft.
Width of boiler room	118 ft.
Distance from basement to turbine-room operating floor	35 ft.
Distance from basement to boiler-room operating floor	27 ft.
Distance turbine floor to lower chord of roof truss	44 ft.
Ratio of boiler-heating surface to boiler-house floor area	6:1
Boilers arranged in two rows parallel to turbine room, facing common firing aisle—width of firing aisle	23 ft.
Width of passage behind boilers next to turbine room	25 ft.
Width of passage behind boilers next to outside wall	12 ft.
Width of passage between boilers	12 ft.

BOILERS AND SUPERHEATERS

Manufacturer of boilers	Babcock & Wilcox Co.
Type	Cross-drum
Steam drum, one	60-in. x 27 ft.
Plate	1 1/16-in. thick
Tubes: Number of, 702; dia., 4 in.; hot finished seamless No. 8 gage—2 lower rows No. 7 gage	
Heating surface	15,964 sq.ft.
Superheaters, Foster	Power Specialty Co.
Superheater surface	5,000 sq.ft.

Superheater performance:

Rating of Boiler, per Cent	Superheat, Deg. F.
100	140
160	160
200	180
250	188

Grate area projected	265 sq.ft.
Boiler-heating surface per sq.ft. grate area	60 sq.ft.
Boiler-heating surface per sq.ft. superheater surface	3.19 sq.ft.
Superheater surface per sq.ft. grate area	18.85 sq.ft.
Boiler-heating surface per installed kw. normal capacity of generators (ultimate)	2.55 sq.ft.
Pressure pounds per sq.in. (gage)	280
Total steam temperature, deg. F	595.9

Coal Analysis:

Fixed carbon	71.00 per cent
Volatile hydro-carbons	17.75 per cent
Sulphur	2.00 per cent
Moisture	00.25 per cent
Ash	9.00 per cent
B.t.u. per lb. (dry fuel)	13,800
Fusing point of ash	2,700 deg. F
Boiler settings all fire brick — no arches	27 ft. 2 in., x 21 ft. 8 in.
Steam jets used in side walls along line of stokers and back walls to prevent clinking.	

BOILERS AND SUPERHEATERS—CONTINUED

Height to center of steam drum above firing-aisle floor	35 ft.
Height to low header from firing aisle floor	14 ft. 7 in.
Insulating brick (Sil-O-Cel) thickness	4 in.
Outside of insulating brick, asbestos mill board, thickness	¼ in.
Steel casing on outside	
Combustion furnace volume	5,194 cu.ft.
Combustion furnace volume per sq.ft., grate area	19.6 cu.ft.
Combustion furnace volume per stoker retort	407 cu.ft.

Boiler Rating Per Cent	Pounds of Coal Fired per Hour per Cu. Ft. Fur. Vol.
100	1.06
150	1.65
200	2.36
250	3.25

	Total	Per Sq. Ft. Grate Area
Free area opening first pass	80 sq.ft.	0.302
Free area opening second pass	50 sq.ft.	0.188
Free area opening third pass	40 sq.ft.	0.151

STOKERS

Manufacturer	American Engineering Co
Type	Taylor BA 7
Number of retorts	13 extra long
Stoker drive. Motor 15 hp	250-volt d.-c. adjustable-speed
Clinker Grinders	American Engineering Co.
Type	Double roll.
Clinker-grinder drive. Motors — two 7½-hp	250-volt d.-c. adjustable-speed

Stoker performance (based on coal 13,800 B.t.u.)

Boiler Rating	Combined Boiler and Furnace Efficiency	Pounds Coal per Retort per Hr.	Pounds Coal per Sq. Ft. Grate Area per Hr.	Air Cu. Ft. per Min. At 65 Deg. F.
100	75	427	19.4	18,800
130	74	660	30.0	28,900
200	69	947	43.0	40,900
250	62.7	1,300	59.0	56,000

Four-hour continuous capacity: 250 per cent.

COAL-HANDLING EQUIPMENT

Railway cars dump into hoppers which feed semi-automatic balanced skip hoists delivering coal to Jeffrey crusher. Coal fed from crusher to belt conveyor which distributes to bunker.
Conveyors, belt, 30-in.; ultimate 2, capacity each, 100 tons per hr.

COAL BUNKERS

Type	Suspended steel, cement lined
Installed kilowatts per ton bunker capacity (ultimate)	31.25
Number of days storage at normal operation	3.5
Bunker capacity per stoker retort tons	15
Yard storage (ultimate)	200,000

FORCED-DRAFT FANS

Manufacturer	B. F. Sturtevant Co.
Number installed	2
Type	Radial flow, double inlet
Capacity	250,000 cu.ft. per min.
Drive	Westinghouse geared turbine
Size	375 hp.

Forced-draft fan performance:

Cu. Ft. per Min.	Static Pressure in Water	Horsepower	R. P. M.
125,000	3	92	330
187,000	4½	205	450
200,000	6	282	462
250,000	6	365	520

Fan capacity per sq.ft. of grate area, (one fan for 4 boilers)	236 cu.ft.
Fan capacity per cu.ft. furnace volume (one fan for 4 boilers)	12 cu.ft.

DATA ON PRINCIPAL EQUIPMENT SEWARD POWER STATION OF THE PENN PUBLIC SERVICE CORPORATION—Continued

MAIN TURBINES

Manufacturers	Westinghouse Elec. & Mfg. Co.
Number installed	2
Type	Horizontal — semi-double flow
Capacity — 25,000-kva. 0.80 P.F., 60-cycle 3-phase 11,000-volt	
Dimension: Length 47 ft. 6 in. width, 17 ft. 9 in., floor area 844 sq.ft.	
Total shipping weight	800,000 lb.
Capacity per sq.ft. of floor space	23.7 kw.
Weight of turbine per rated kilowatt	40 lb.
Speed	1,800 r.p.m.

TURBINE PERFORMANCE

Load	Vacuum Referred to 30 Bar. 29 in.	28 in.
	Pounds per Kw.-hr.	
10,000	12.08	12.75
15,000	11.40	11.71
20,000	11.71	11.78

CONDENSERS

Manufacturers	Westinghouse Elec. & Mfg. Co.
Type	Le Blanc low-level jet.
Number	One—No. 39 twin, for each unit.
Length of connection between turbine exhaust and condenser	20 ft.
Condenser support	Set on floor

Water-cooled rubber expansion joint between turbine and condenser.

Circulating pumps. 1 double runner Westinghouse centrifugal for each half of condenser.

Drive	Turbine through gears
Capacity	28,000 g.p.m. per unit
Capacity per kw	2.8 g.p.m.

Air pumps: Steam-ejector type, 7 units for each twin condenser

Condenser for air ejectors, submerged mixing type.

Condenser performance with condensing water at 70 deg. F.:

Lb. Steam Condensed per Hr.	Vacua
190,000	28.57
215,000	28.53
240,000	28.47

Intake: Direct from river. Skimming lip below water level to deflect floating rubbish. Screen house provided with bar screens to remove larger rubbish.

Intake screens: 2 traveling, Link-Belt Co.; effective screening width 6 ft. 7 in., mesh ½ in.

Drive: One 3-hp. motor for each screen

Total weight of screens, 24,000 lb. each

Intake and discharge tunnels under station of rectangular cross section.

MISCELLANEOUS EQUIPMENT

No.	Equipment	Capacity	Type	Manufacturer
2	Boiler-feed pump..	750 gal.per min.	4-stage centrifugal	A. S. Cameron Steam Pump Works
2	Boiler-feed turbines	225-hp.....	Geared.....	Westinghouse Elec. Mfg. Co.
1	Feed-water treating system.....	60,000 gal. per hr.....	Sorge hot-process	Harrison Safety Boiler Co.
6	Boiler-feed meters.	4-in. two per boiler.....	Venturi.....	Simplex Valve & Meters Co.
1	Feed-water meter.	Total boiler feed.....	V-notch.....	Harrison Safety Boiler Co.
	Feed-water tanks..	40,000 gal. exclusive of treating tanks	.....	Petroleum Iron Works
	Furnace insulation	.....	Sil-O-Cel.....	Celite Products Co.
	Smoke flues and forced-draft ducts	.....	Steel.....	Welch's Holyoke Steam Boiler Works
	Pipe covering.....	.....	85% magnesia...	Keasby & Mattison

MISCELLANEOUS EQUIPMENT—Continued

	Coal crusher.....	100 tons per hr.	Single roll.....	Jeffery Mfg. Co.
	Coal elevators.....	100 tons per hr.	Semi-automatic balanced skip hoist.....	C. W. Hunt Co.
	Coal conveyor....	100 tons per hr.	Belt with automatic traveling tripper.....	Robins Conveying Belt Co.
9	Ash gates.....	5 ft. x 5 ft.....	Air operated....	Baker, Dunbar-Allen Co.
1	Stack.....	17 ft. inside diam. 300 ft. above boiler-room floor...	Self-supporting steel, brick lined.....	American Bridge Co.
	Soot blowers.....	.....	10 units per boiler	Vulcan Mfg. Co.
	Fan control.....	.....	Controlled by steam pressure	The Hagan Corp.
	Boiler damper regulators, main dampers.....	.....	Controlled by steam pressure	The Hagan Corp.
2	Boiler stoker dampers.....	.....	Controlled by furnace pressure	The Hagan Corp.
1	Exciter turbine....	300-hp.....	.....	Terry Turbine Co.
2	Feed-pump governors.....	.....	Copes.....	Northern Equipment Co.
6	Boiler-feed controllers.....	2 per boiler...	Stetts.....	Williams Gage Co
2	Steam-flow meters	.....	Indicating and recording.....	Republic Flow Meter Co.
2	Oil purifiers.....	100 gal.per min.	Centrifugal.....	De Laval
3	Draft gages.....	.....	3 in one.....	Precision Instrument Co.
1	Traveling crane...	50-ton main hoist, 10-ton auxiliary hoist	.....	Niles-Bement-Pond Co.
3	Flue-gas equipment	.....	Orsat.....	Precision Instrument Co.
	Main steam valves	.....	.....	Pittsburgh Valve Foundry & Construction Co.
1	Back-pressure valve	20 in.....	.....	Pittsburgh Valve, Foundry & Construction Co.
6	Automatic-stop valves.....	.....	.....	Edward Valve & Mfg. Co.
12	Blow-off valves...	.....	.....	Cadman Mfg. Co.
9	Relief valves.....	.....	.....	Atwood & Morrell
	Standard weight gate valves.....	.....	.....	Fairbanks Co.
2	House-service pumps.....	350 gal per min.....	Centrifugal, motor-driven..	A. S. Cameron Steam Pump Works
1	House-service pump	750 gal per min.	Centrifugal, turbine driven....	Buffalo Steam Pump Co.
1	Air compressor....	500 cu.ft. per min.....	Reciprocating, motor driven..	Sullivan Machinery Co.
6	Sump pumps.....	3—100 gal.... 1— 50 gal.... 2—350 gal....	Vertical centrifugal.....	Rumsey Pump Co
6	Boiler-feed Meters.	.....	.....	Simplex Valve & Meter Co.
	Recording wind-box gage.....	.....	.....	Foxboro Co.
2	Generators.....	20,000-kw. at 0.80 P.F....	.....	Westinghouse Elec. & Mfg. Co.
	Auxiliary-power transformers....	1,200-kva.....	3-phase, indoor..	Westinghouse Elec. & Mfg. Co.

Practically all of the remaining electric equipment was furnished by the General Electric Company. Steel globe and check valves and steel unions, Edward Valve and Mfg. Co. Main and auxiliary steam piping, steel and Monel metal gate valves, Pittsburgh Valve & Foundry Construction Co. Circulating-water, atmospheric-relief and safety-valve bent piping, Crane Co. Standard-weight piping, Power Piping Co. Rubber expansion joints in circulating-water piping, U. S. Rubber Co. Special oil-treated studs for pipe flanges, Oliver Iron and Steel Co. Copper expansion joints, E. B. Badger Co.

A steam turbine which is started up after a short rest is likely to vibrate violently on account of the distortion from the superheated exhaust by reason of the light load and the heated condition of the machine. If it is allowed to stand a sufficient length of time it will start up with its usual smoothness.

A boiler may empty itself overnight, or, if the blowoff cock or feed valve is leaky, the boiler may empty itself while steam is being raised. It is, therefore, imperative that the water-gage glass should be tested before starting fires and should be watched while raising steam; it should also be carefully watched during working hours, even if automatic feed regulators and low-water-level alarms or safety valves are fitted.—*Manchester Steam Users' Association.*

A spray pond should have 2½ sq.ft. of area per gallon of water to be cooled per minute. This includes the marginal strips necessary for windage, etc.

Voltage Characteristics of Direct-Current Generators and Their Bearing on Parallel Operation

By EUSTIS H. THOMPSON

WHEN several direct-current generators are operated in parallel, the distribution of the external load between the different machines is fixed by the internal resistance and the terminal voltage of each machine. It is, therefore, important to consider the factors that affect the terminal voltage and the adjustments and misadjustments that may improve or impair their operation in parallel. For this purpose a brief study will be made of the voltage characteristics of the direct-current generator. For the sake of simplicity a shunt generator will be considered; that is, a generator in which the field exciting winding is connected across the brushes.

If a shunt generator is brought up to normal voltage on open circuit, say 220 volts, and then gradually loaded up to full load, the voltage will drop an appreciable amount; under ordinary circumstances this drop would probably amount to 10 or 15 volts. The causes of the voltage drop are as follows: (1) Slower speed at full load necessary to provide governor regulation of the prime mover; (2) resistance of the windings, commutator, brushes and connections; (3) armature reaction that to some extent demagnetizes the field and this lowers the voltage; (4) lower value of shunt-field current resulting from lower voltage at the brushes of the machine, due to the foregoing causes.

In the parallel operation of direct-current generators considerable trouble is often experienced through the tendency of one machine to take more or less than its share of the outside load. This is due sometimes to the inherent characteristics of the machine and sometimes to faulty brush setting or other internal factors affecting the voltage drop under load. These factors and the adjustments that may sometimes be made to correct the trouble in machines with and without interpoles are discussed in this article.

The effect of speed on the voltage of a generator is well known. The voltage generated in a conductor depends on the amount of magnetic flux that it cuts through in one second. Other conditions being equal, it follows that the voltage varies directly as the speed for generators that have a constant field. In shunt generators the voltage drops to a greater extent than the speed, owing to the fact that the shunt field is connected across the brushes and therefore is not constant itself, but decreases to some extent with the voltage of the brushes. This factor is covered by condition No. 4. Neglecting the decrease in field strength, if the generator voltage drops a given percentage from no load to full load with a governor regulation of 4 per cent—that is, with full-load speed 4 per cent lower than no-load speed—it will drop more than this if the governor regulation is increased to 9 per cent. In this case we will have the full-load speed 5 per cent lower than in the first case, and we would expect the full-load voltage to be at least 5 per cent lower than with the shorter governor regulation.

Fig. 1 is a conventional diagram of part of a multipole double-layer lap-wound armature, in which the conductors in the top layer are shown in full and those in the bottom layer in dotted lines. Fig. 2 is a cross-section of the same portion of the machine, showing the path of the magnetic flux through the armature under no-load conditions; that is, with only the shunt field current flowing through the armature windings. Under these conditions the magnetic effect of the armature is negligible.

The arrows in Fig. 1 show the direction of the voltage generated in the different coils of the winding under the different poles. By tracing out the winding from brush to brush it may be seen that the coils between any pair of brushes are all in series and generating voltage in the same direction. Therefore, the terminal voltage of the machine, or voltage between brushes, is the sum of the voltages generated in each coil between brushes. As the number of coils between different pairs of brushes is the same and the total amount of flux leaving each north pole or entering each south pole is practically the same, the voltage generated between different pairs of brushes will be equal in amount, though opposite in direction under north and south poles. The result will be to make adjacent brushes alternately positive and negative. All the positive brushes are connected together and to the positive terminal of the machine, and the negative brushes to the negative terminal, as shown in Fig. 1. Under no-load conditions the magnetic field produced by the shunt windings is practically symmetrically distributed in the air gap, as illustrated in Fig. 2. Curve *A*, Fig. 3, shows the flux density at different points in the air gap under these conditions. At the instant shown in Fig. 1, coil *X* is halfway between two poles and is cutting no magnetic flux from the field; it is, therefore, generating no voltage. This may be clearly seen from Fig. 2. This position is known as the mechanical neutral. The magnetic neutral is the point where there is no flux in the air gap—that is, where the flux density is zero—and at no load the magnetic neutral coincides with the mechanical neutral.

When the generator is loaded to full capacity, current flows through the armature winding, and this current tends to set up a magnetic field of its own. The magnetomotive, or "flux-producing," force of the armature winding with the brushes on the mechanical neutral is illustrated in Fig. 3, curve *D;* and the flux density that would be produced thereby in the air gap if the shunt field were unexcited is shown by curve *B*. Therefore curve *B*, Fig. 3, shows the flux distribution produced by the armature when the shunt-field winding carries no current, and curve *A* the flux distribution produced by the shunt field when the armature winding carries no current. From curve *B* it is seen that the armature winding tends to produce flux in the same direction as the shunt field under one-half of the pole

face and in the opposite direction under the other half. The net flux density produced by the field and armature windings together when they are both carrying current is the sum of curves *A* and *B* and is given by curve *C*. From this curve it may be seen that the trailing edge of each pole is strengthened and the leading edge weakened by the armature reaction. This result is known as distortion of the field, and the magnetic reaction that produces it is called cross-magnetizing armature reaction. This effect is symmetrical with respect to the center of the pole face, and the armature tends to strengthen one half of the field under one pole exactly as much as it tends to weaken the other half. There is, however, a slight loss in total flux, owing to the saturation of the iron in the magnetic circuit, that makes the gain under one half of the pole face less than the loss under the other half. It is also clear from curve *C* that the magnetic neutral, or point of zero flux density, has been shifted to *E*. The conditions necessary for sparkless commutation in a generator without interpoles under load require that the brushes be shifted in the direction of rotation, so as to delay the short-circuiting of the coil about to undergo commutation until its conductors *XX* come within the edges of the flux from the field pole (see Fig. 4). Let *F* be the full-load axis of commutation, and let the brushes be shifted to this new position, as shown in Fig. 4. The whole magnetic reaction of the armature is now shifted with respect to the field poles; the weakening effect produced by the shaded area *P* in the armature magnetomotive-force curve is greater than it was when the brushes were on the mechanical neutral; whereas the strengthening effect due to the shaded area *Q* is less than in the former case. The net result is a weakening or demagnetizing of the field. This effect is clearly shown from another viewpoint in Fig. 4. Conductors on one side of the mechanical neutral contained within shaded areas *R* have a direct demagnetizing effect on the south poles of the field, as may be seen by comparing the directions of current flow in these conductors and in those of the winding on the south field pole; and the conductors contained within areas *T* have a demagnetizing effect on the north pole. The conductors outside of these areas are symmetrical with respect to the center line of the field pole, and they strengthen the trailing pole tip and weaken the leading pole tip. Their effect is, therefore, cross-magnetizing. The armature reaction is now partly demagnetizing and partly cross-magnetizing.

Shifting the brushes in the direction of rotation from the mechanical neutral, therefore, gives the armature a direct weakening effect on the field as load is applied, and this effect is proportional to the load. It will, therefore, cause the terminal voltage to drop more rapidly than when the brushes are left on the neutral axis. It may be shown also that shifting the brushes from the mechanical neutral against the direction of rotation has the opposite effect and gives the armature a direct magnetizing effect on the field proportional to the load, as if the generator field included a series winding, and would give the shunt generator the characteristics of a compound machine, if it could be so used in practical operation. This cannot be done, however, in any machine without seriously impairing commutation. Interpoles are placed on direct-current machines to provide a commutating field, the object of which is to reverse the current in the coil under commutation, so that the brushes may be left on the mechanical neutral as the load increases. If the interpoles are correctly designed, the brushes on an interpole machine should always remain on the mechanical neutral, yet many operators are tempted in practice to shift them slightly. Aside from their effect on commutation the interpoles may have a marked effect on the terminal voltage if the brushes are shifted even slightly from the mechanical neutral. Referring to Fig. 5, the conductors passing through the shaded areas under a north interpole are generating voltage in the same direction as those moving under a north main pole and in the opposite direction to that of the conductors moving under a south main pole. With the brushes set on the mechanical neutral as in Fig. 5(a), of all the conductors in series between brushes, there are as many cutting flux from a south as from a north interpole, and the voltages generated under the interpoles oppose and neutralize each other; the interpoles, therefore, have no effect on the terminal voltage. Now

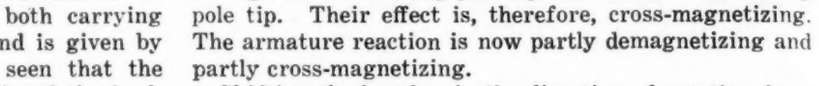


FIG. 2. CROSS-SECTION OF DIRECT-CURRENT GENERATOR SHOWN IN FIG. 1

Illustrating the path of the magnetic flux through field and armature at no load; that is, with only the shunt-field current flowing through the armature winding. This current is so small that its magnetic effect is negligible, and the flux is practically uniformly distributed under the polepieces. Note that *M*, the mechanical neutral axis—that is, the axis halfway between the polepieces—coincides with the point of zero flux density in the air gap. At no load, therefore, the mechanical and magnetic neutrals coincide.

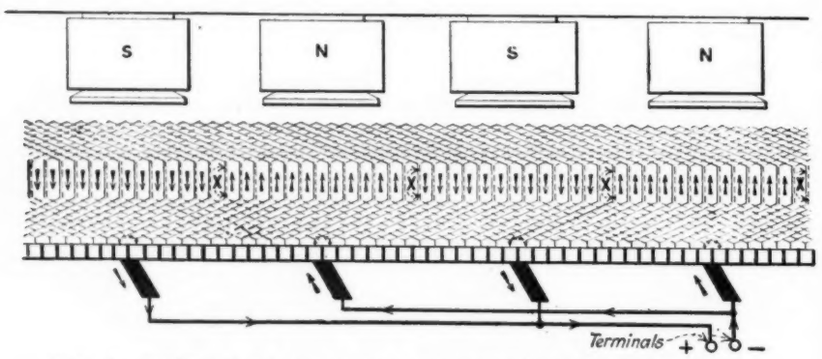


FIG. 1. WINDING DIAGRAM OF A MULTI-POLE DIRECT-CURRENT GENERATOR WITH A DOUBLE-LAYER LAP-WOUND ARMATURE

shifting the brushes forward, as in Fig. 5(b), decreases the number of conductors under interpoles generating voltage in the same direction as the main pole and increases the number generating voltage in the opposite direction from the main pole. The interpoles, therefore, no longer neutralize each other, and the net voltage generated by them subtracts from that of the main poles all around the armature. Therefore, as the load increases and the interpoles become stronger, the terminal voltage of the machine will drop more rapidly than when the brushes are on the neutral axis.

If the brushes are shifted against the direction of rotation as shown in Fig. 5(c), the reverse will happen, and the net voltage generated by the interpoles will be added to that due to the main poles; the machine will compound, as the load increases, as if it had a series-field winding. The voltage characteristics of the machine may in this way be varied to an appreciable extent by shifting the brushes slightly one way or the other, but this is usually very bad practice and will in all probability impair commutation. It may sometimes be necessary, however, in cases of faulty design, where the interpoles are either too strong or too weak, and the machine sparks. The effect should, anyway, be borne in mind in the parallel operation of direct-current gene-

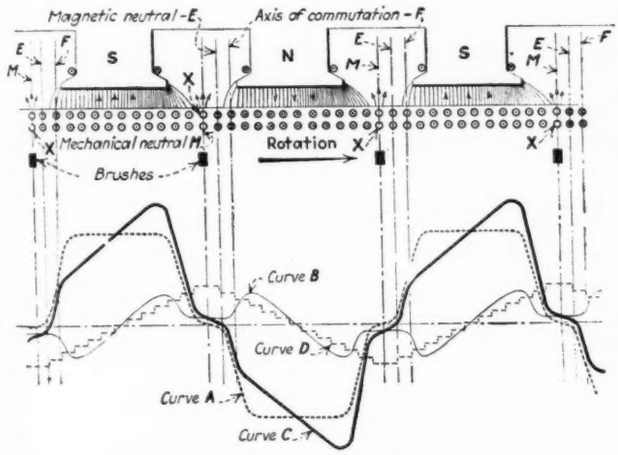


FIG. 3. FULL-LOAD ARMATURE REACTION IN SHUNT GENERATOR WITH BRUSHES ON THE MECHANICAL NEUTRAL

Curve *A* gives the flux density in the air gap produced by the shunt field, when the armature winding carries no current; that is, at no load. Curve *B* gives the flux density that would be produced by full-load current in the armature winding if the field winding carried no current; that is, if the machine were unexcited. Curve *C* gives the flux distribution produced when both shunt-field and armature windings carry current; that is, with the machine under full load and full excitation. It is the sum of curves *A* and *B*. Curve *D* shows the distribution of magnetomotive, or "flux-producing," force of the armature winding.

Note the shifting of the magnetic neutral, or axis of zero flux density, under load, from its position at *M* at no load to *E* at full load. The armature reaction is symmetrical with respect to the center line of the polepiece; it is all cross-magnetizing and has little effect on the terminal voltage.

rators, for the tendency of one machine to take more or less than its share of the load may often be traced to faulty brush setting.

Effect of Magnetic Saturation

The degree of saturation of the iron in the magnetic circuit of a generator has an important effect on its voltage variations under load. The term "saturation" is applied in practice to the condition of the iron when its "permeability," or ability to conduct magnetic flux, decreases rapidly with increasing flux density. If a 220-volt generator is operated at normal speed and no load and its exciting current varied gradually from 0 to its maximum by gradually cutting out the field rheostat, the terminal voltage will increase approximately as the exciting current up to a certain point. Beyond this point it will take more and more increase in field current to produce the same increase in voltage. For instance, it may take about six times as much increase in field current to raise the voltage from 240 to 241 volts

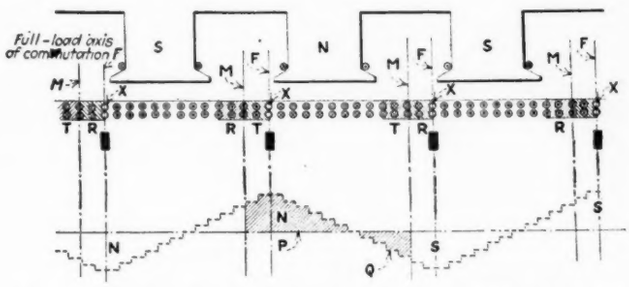


FIG. 4. EFFECT OF SHIFTING BRUSHES FORWARD ON ARMATURE REACTION IN SHUNT GENERATOR

The armature reaction is non-symmetrical with respect to the center line of the polepiece, as shown by the magnetomotive-force curve. Area *P* of the magnetomotive-force curve opposes the shunt field, area *Q* assists it. The net effect is to weaken the field as the load on the machine increases. The armature reaction is partly cross-magnetizing and partly demagnetizing. Conductors included in areas *R* and *T* have a directly demagnetizing effect respectively on the main south and north poles, as may be seen by comparing the direction of current flow in these conductors and in the field winding.

as to raise it from 100 to 101 volts. Fig. 6 shows a typical "saturation curve"; that is, a curve plotted between field excitation and terminal voltage in a generator. Above 150 volts, the iron shows signs of approaching saturation, and the curve drops off rapidly from the straight line.

Generators are usually designed to operate well above the "knee" of the saturation curve. This means that the iron in the field must be partly saturated when the machine is operating at rated voltage. The reason for this will be plain from a brief study of Fig. 6. Let the field excitation in ampere-turns per pole necessary to produce 220 volts at the machine terminals at full load be taken as 100 per cent. Assume the demagnetizing reaction of the armature in ampere-turns—that is, the armature current multiplied by the number of turns included in areas *R* or *T*, Fig. 4—to be 9 per cent of full-load excitation. The full-load field excitation minus the armature reaction gives the net excitation at full load; that is, 100 — 9 = 91 per cent (see Fig. 6). But the voltage generated by 91 per cent excitation is 230 volts, whereas that corresponding to 100 per cent would be 237 volts. Therefore the voltage loss due to the demagnetizing effect of the armature is in this case about 7 volts. If the machine were being operated at full-load current under 110 volts instead of 220, the full-load excitation at half-voltage, as taken from the curve, would be only 35 per cent of that required at full voltage. The armature reaction at full load remains the same; the net excitation will, therefore, be 35 — 9 = 26 per cent. But the voltage generated by 26 per cent excitation is only 118, whereas that due to 35 per cent is 159 volts; the loss of voltage due to the armature reaction at half-voltage will therefore be about 41 volts, as against 7 at full voltage.

It will be clear from this discussion why generators that are "low on the saturation" show wide variations of terminal voltage under variable loads and are, there-

fore, very unstable in parallel operation with other machines. Machines that are unusually "high on the saturation" may give trouble owing to the large amount of excitation necessary to compensate for the different causes of voltage drop. If a sufficient margin has not been allowed in proportioning the field windings and rheostat, it will be impossible to keep the voltage up to normal under load. However, both too low and too high a degree of saturation in a new machine are due to faulty design, and these conditions are unusual in up-to-date machinery. Should they be detected in a machine, the manufacturer should be consulted.

In the foregoing discussion the "cross-magnetizing" effect of the armature has been ignored, as its effect on the terminal voltage is important only in machines that are operated directly on the "knee" of the saturation curve, a condition which is avoided by all reputable designers.

Parallel Operation of Shunt Generators

As was mentioned at the beginning of this article, the ideal condition for good multiple operation of shunt generators requires the same voltage drop in each machine from no load to full load and the resistance of the windings and connections to be proportional to the rated capacity of the machines. They will then divide the load in direct proportion to their capacity. These conditions can only be approximated in practice, and it is usually found that, though the internal resistances of two machines may be made proportional to their capacities, slight differences in magnetic characteristics will change their voltage regulation. It is then necessary to compromise and to adjust the field rheostat of the

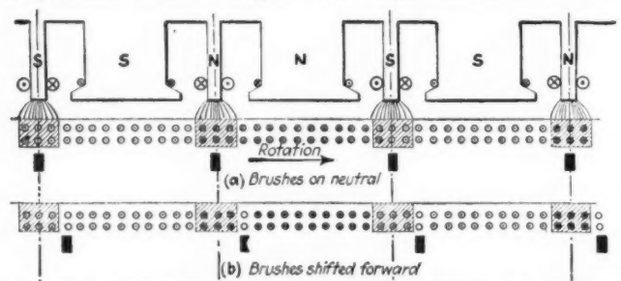


FIG. 5. EFFECT OF BRUSH SHIFTING IN INTERPOLE GENERATORS

(a) Brushes on Neutral: The interpoles have no effect on the terminal voltage, because the voltages generated under north and south interpoles neutralize each other.
(b) Brushes Shifted Forward: The interpoles cause a drop in voltage as the load increases, because the voltages generated by them no longer neutralize each other, and the balance opposes the voltage generated by the main poles.
(c) Brushes Shifted Backward: The interpoles cause compounding, like a series-field winding, because the balance of voltage generated by the interpoles is added to that generated by the main poles.
Note that the dots and crosses indicate the direction of the voltage generated in each conductor, and not the current flow.

machine with the poorer regulation so that it will take more than its share at part loads in order that it may take its full share at full load.

Trouble in general would be expected from: (a) Resistance of brush contact with the commutator (commutation troubles may change the contact resistance between brushes and commutator and prevent proper operation); (b) in proper proportioning of winding resistance; (c) deterioration or change of shunt-field windings or rheostat, etc.; (d) looseness or deterioration of the various elements of the magnetic circuit, such as rusted shims, etc.; (e) the same with elements of the electrical circuit; (f) incorrect brush setting.

When the shunt generators are equipped with interpoles, the same conditions of voltage and resistance hold

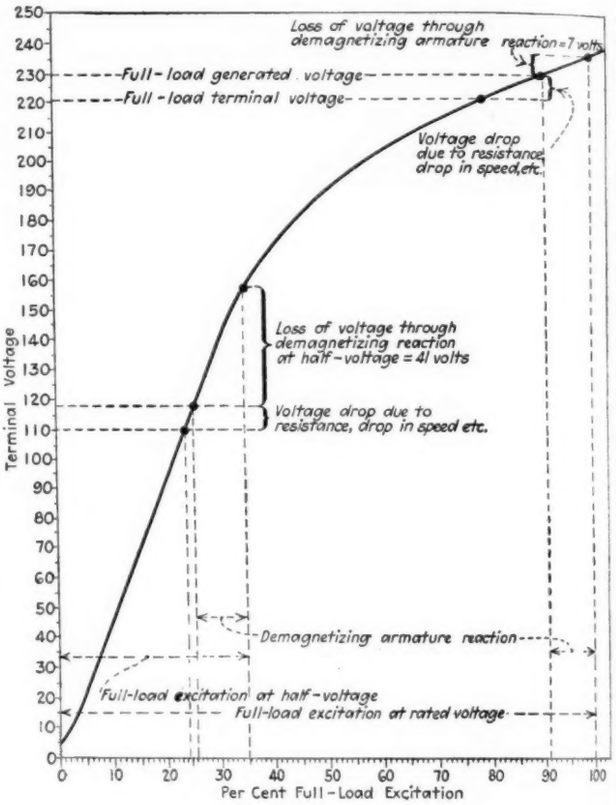


FIG. 6. TYPICAL SATURATION CURVE OF DIRECT-CURRENT GENERATOR

Showing why generators with low saturation of the iron give wide variations in voltage under load. When operated at 220 volts, the machine loses 7 volts at full load by armature reaction; when operated at 110 volts, the same machine loses 41 volts by armature reaction.

good for proper multiple operation. However, the brush setting plays a much more important part, owing to the compounding effect of the interpole.

The opening of steam valves and drain cocks should be done carefully, as many steam-pipe explosions have occurred when one boiler attendant has been replaced by another who was unaware of the order in which the valves and cocks were opened and closed. The attendant should take it for granted that all low-lying steam pipes, especially long ones, all low-lying bends, junction valves, and all pipes between bulb valves are pockets in which water has settled while idle, and that large volumes of water will condense as soon as steam is turned into them. This water must be removed slowly, and very often much water in a pipe helps to create a vacuum, and as there is then no outflow a fairly full pipe may be thought to be empty. A safe plan for coupling up a steam-pipe range is as follows: Open the drain cocks; these will either drain away the cold water or admit the air, which, if a water hammer should occur, will soften the blow. Close the cocks before opening the steam valve slightly. After a time close the steam valve and reopen the drain cocks. These operations may have to be repeated several times.—*Manchester Steam Users' Association.*

Causes of Pounding in Four-Stroke-Cycle Semi-Diesel Engines

By D. L. Fagnan

Not long ago I was called upon to solve the difficulties that beset the operation of a four-stroke-cycle semi-Diesel, or surface-ignition oil engine. The engine, which was a 100-hp. single-cylinder unit, was carrying its rated load but pounded badly. On low loads the pound died out, but as the load increased the pound grew stronger until at full load it was decidedly severe.

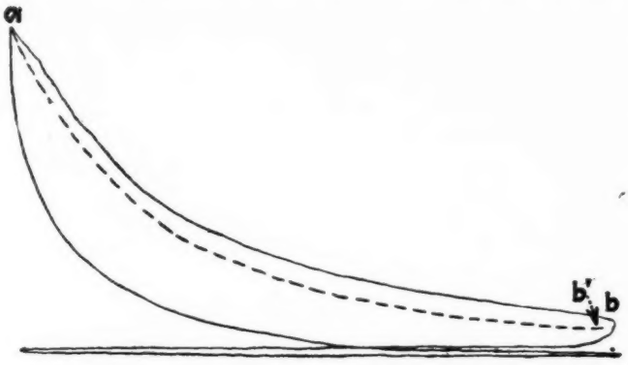


FIG. 1. INDICATOR DIAGRAM SHOWING HIGH TERMINAL PRESSURE

The operator was in the habit of feeding heavy amounts of lubricating oil to the cylinder, whereupon the pound would gradually die down, but after an hour or so it would start again, while the exhaust would smoke badly.

Upon examination I found the piston rings gummed, especially the two top ones, which were locked fast in the grooves. This naturally allowed part of the air on the compression stroke to blow by the piston, causing the compression pressure to be too low for complete combustion of the fuel. It should be understood that the heavy portion of the oil charge will not burn unless the compression pressure and temperature are sufficiently high. With a loss of part of the air charge during compression, there was not enough air left in the cylinder to burn the fuel completely even if the temperature were high enough. Most oil engines have a cylinder volume to give 50 per cent excess of air for full load, but it does not take much leaking along the piston to eliminate this excess.

Since the air charge was insufficient to cause complete combustion, the engine, of course, tended to slow down on full load. The governor thereupon caused the fuel pump to inject a greater charge of oil. The result was that the pressure in the cylinder during expansion did not drop so rapidly as under normal conditions. The expansion line was similar to *ab* in Fig. 1, while the normal expansion should be ab^1. The high pressure at *b* caused a large force to be exerted on the area of exhaust valve; this produced a heavy pound as the cam struck the exhaust-valve rocker arm and opened the valve against this high pressure.

The smoky exhaust proved that the engine compression was not good, for it is an axiom that no oil engine will smoke when in good condition, with tight valves, tight piston, free piston rings and the proper compression. An oil engine is not overloaded from the operating point of view until the amount of fuel injected into the cylinder is more than the air charge can handle.

The feeding of excessive amounts of lubricating oil helped to loosen the rings and seal the compression, and for a time the engine ran quite well. But this excess of lubrication again left deposits on the cylinder and piston which resulted in the rings becoming gummed a second time. The trouble was soon remedied, however, by putting the engine in first-class mechanical condition.

In this case, as in all other cases of engine trouble, the operator could have discovered the defect if he had an indicator, with which low compression can be quickly detected by connecting the indicator to the cylinder. It is not necessary to hook up the reducing motion since the height of the pencil line made during compression will reveal any loss of air. In Fig. 2 *A* is a series of compression pressures taken on a 17 x 27½-in. semi-Diesel engine. The compression, instead of 300 lb. as normal with this engine, showed not over 225 lb. By cleaning the piston and installing two new rings, the compression came back to normal, as appears in Fig. 2*B*. In getting compression diagrams the fuel pump must be cut out. This can be done even on full

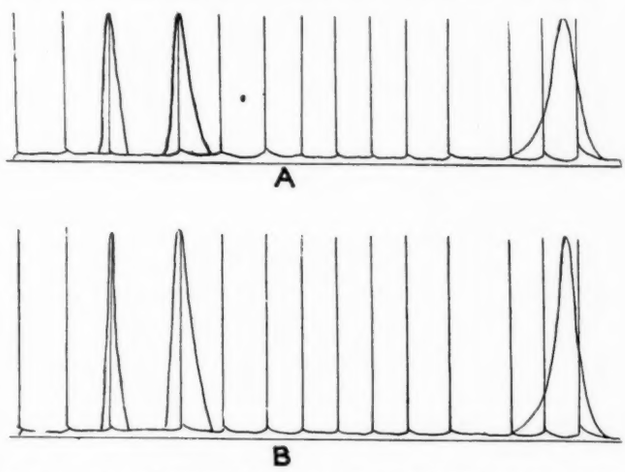


FIG. 2. COMPRESSION DIAGRAMS, *A* SHOWING LOW COMPRESSION AND *B* SHOWING CORRECT COMPRESSION

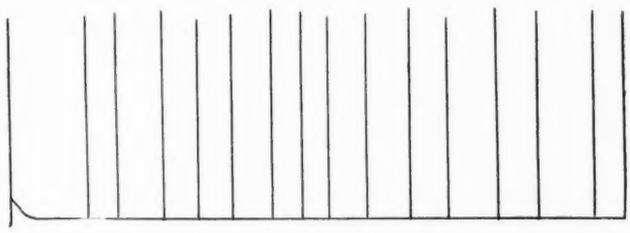
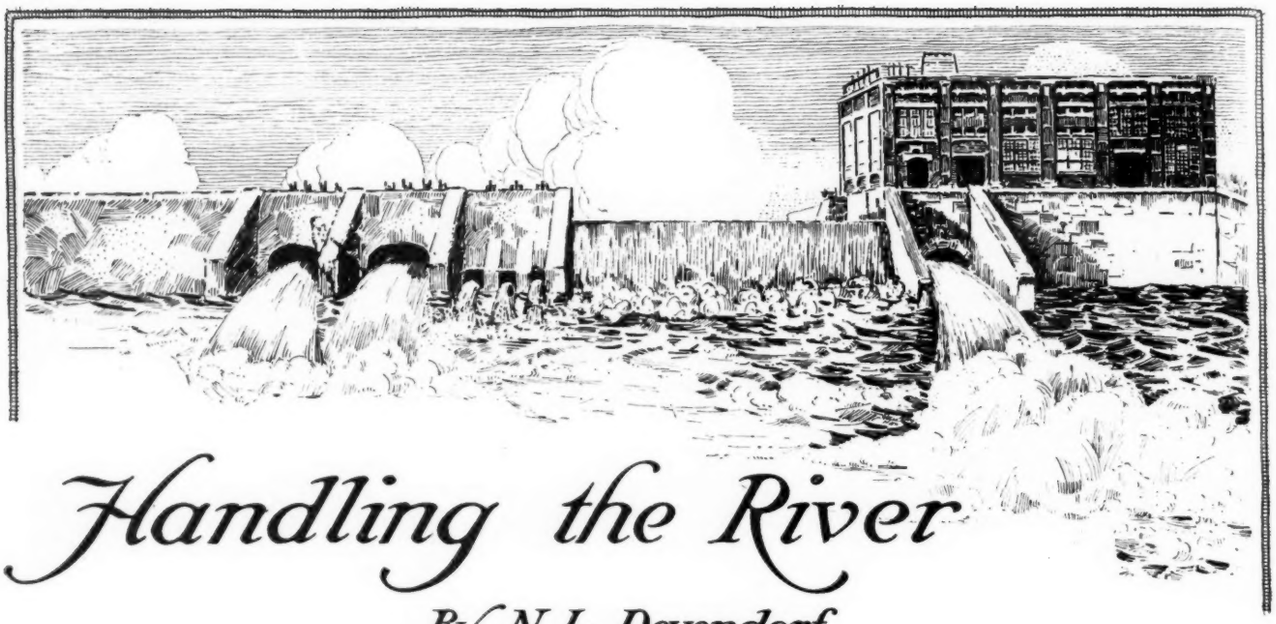


FIG. 3. EXPLOSION DIAGRAM

load since a diagram can be made in ten seconds, and the engine will not drop much in speed.

The explosion pressure can be secured in the same way while the engine is firing. Such a diagram is shown in Fig. 3, which is taken from a 20 x 34½-in. engine with a 300-lb. spring scale.

Many of the troubles with internal-combustion engines are directly due to the use of a cheap lubricating oil. In one plant where trouble was always occurring, I found that a cheap red oil costing 37 cents a gallon was being used. This oil was entirely unsuited for such high-temperature use. Heavy carbon deposits settled on the piston, rings and valves. The engine could not pull the load. A high-grade lubricating oil especially compounded for oil engines eliminated all the trouble.



Handling the River

By N. L. Devendorf

THE modern hydro-electric plant is usually designed with sufficient generator capacity to take care of the normal flow of the stream, so that the whole of its profitably salable energy may be utilized. There is, however, a certain amount of water that it would be unprofitable to use by reason of the short time it is available. The income from the use of this surplus flow would not pay the charges on the cost of the additional equipment necessary to handle it.

If there is in the operating routine of the plant a reliable prediction of stream flow a day ahead, there will be warning of an impending freshet. If the plant is connected with a transmission system and is not running at full capacity for twenty-four hours a day, additional load should be taken and the pond drawn down to take care of all, or as much as possible, of the water that is coming down. If the plant is fully loaded or additional load cannot be obtained, it may be necessary to spill water, but as much as possible of the water passing the dam should generate a revenue-producing load.

In case of an expected flood the operating procedure is simpler if the spillway is of the overflow or rollway type than if it is controlled by gates. In the former case it is a matter of judgment in the economical use of the stream flow and the possible salvage of the flashboards. In the latter case the safety of the gates or the dam itself may be involved, so it is advisable in winter to maintain the headwater level a little below the normal maximum as a safety precaution in case the plant should lose its load by reason of transmission-line trouble or other cause.

In a plant operated by one man, and which feeds into a transmission system, some little time might elapse before he could leave the switchboard to take care of the headgates in case of trouble, and the gates might be frozen so it would be difficult to start them, and with a full pond such delay in raising the gates might be serious.

It must, of course, be a part of the station routine to keep one or more of the waste gates free from ice, either by the application of heat or by keeping the ice chopped away. The method in vogue in some places of building a fire against the gates is not good practice, especially in the case of tainter gates, because it is liable to warp some of the braces and cause the gate to bind or perhaps weaken it. It is obvious that it would be unsafe to "fire" a wooden gate. With any form of gate a fire will burn off the paint and undoubtedly shorten the life of the structure. The cost of "firing" in this manner is something to be considered. Even though all the wood were taken from the stream, the extra labor involved in handling it would run into money.

Kerosene and gasoline torches have been developed for this purpose and look promising for steel gates. The burner is attached to a hose, and the flame is applied along the edge of the gate and wherever necessary to loosen and melt the ice. These torches are not desirable for wooden gates on account of the fire hazard.

Where available, the safest agency for thawing gates is steam. If there is no steam-heating system in the plant, a small boiler, well housed and equipped, a well-insulated steam line along the gate structure with a tap at each gate, and a good hose with a well-designed nozzle, will prove an excellent investment where there is much trouble from frozen gates. In some installations one or more gates are inclosed in such a manner that the housing is raised and lowered with the gate. Steam radiators or coils are attached to the gate, to which steam is led by means of a hose connected to a pipe from the station heating boiler.

Operating difficulties during high- and low-water periods and how to meet them. Guarding against ice and the formation of so-called anchor ice. Various methods of stopping leaks at the dam.

This is an effective method of preventing the formation of ice.

It is a matter of observation that gates with the downstream face to the south are much more easily kept clear of ice than those facing in other directions. It has also been noticed that if the end gates of a series are kept clear and opened first, it will be much easier to free those in the center.

In any work around the gates and spillway it is necessary to exercise caution to avoid slipping and falling into the water. Spiked shoes can be worn to good advantage. In specially hazardous places a safety belt or rope should be used. The practice of tying axes, spuds and similar tools to the person is dangerous, as missing his aim, a man might be thrown off his balance and get a bad fall. Care should also be taken in raising the gates that nobody is working around them or on the dam or apron below, where the spill from that particular gate will catch him.

Preparing for the Big Run-Off

In general, the big flood comes after the danger of frozen gates is about over, but it is well to be prepared at all times. In the overflow spillway, if there are flashboards in place, they should be removed to prevent their being carried downstream and lost or causing the overflow of lands upstream not covered in the flowage rights. The careful hydro-electric operator will look to this and to every part of the structure that will be subjected to the stress and strain of the flood, and have everything ready that experience and common sense tell him may be needed in any contingency that may arise.

This preparation should include pike-poles, rakes, ropes, ice-handling tools, dynamite, means of handling logs or other large obstructions that may be found in the racks, a good, substantial flat-bottomed boat, a life preserver and a practical knowledge of the Prone Pressure Method of Resuscitation for use in cases of apparent drowning.

In some developments flood water having passed the dam may create a considerable hazard by backing up in the tailrace. This is especially true if an ice jam should form below the plant, damming up and raising the water sufficiently to enter doors or windows on the downstream side of the power house. In plants where horizontal direct-connected generating units are installed, special precautions may have to be taken to avoid serious trouble, as the generators and exciters are on the station floor at the same level as the turbine runners and necessarily set rather low down. In the majority of small and medium-sized plants the switchboard also is on this floor.

Closing Floor Openings to Tailrace

Any floor openings to the tailrace must be closed solidly with the iron covers provided, the joint being sealed with a rubber gasket. Doors and windows thus exposed to the possibility of high water should be provided with stop-planks and shutters. The shutters should be so designed that they can be bolted to the window-frame with a watertight joint. The doorways should be provided with a groove in the masonry, or a channel iron, for the stop planks. The planks and shutters should be kept at hand where they will be available on short notice.

A centrifugal sump pump of ample capacity should be so set that the driving motor and mechanism would be unlikely to get wet under any condition. The station drains should be kept clear, so that any water entering through cracks in the walls or otherwise may immediately find its way to the sump.

The preparation and care of this apparatus should be made a part of the periodical plant routine, and everything should be ready for the big run-off a considerable time before it is apparent that it will be needed.

Guarding Against Ice

When the spring flood is accompanied by the breaking up of the ice, as is frequently the case on northern streams, and when the conditions are such that the ice is likely to jam, either above or below the plant, there is ground for more anxiety than when the run-off is merely a large volume of water. The possibilities of high water will have been considered by the designing engineers, and presumably adequate protection, with ample margin of safety, will have been installed. But ice is likely at times to behave in ways that could not well have been foreseen, and while in modern developments it is rare that permanent damage is done to the works, the menace to continuous operation is serious.

When a field of ice breaks loose and starts downstream, meeting but little opposition, it becomes a formidable enemy and must be met with defenses that will stand a heavy onslaught. Ice breakers are in many installations a first line of defense. These are usually of heavy timber construction, filled with rock or concrete. They are built with the top slanting upward from near the normal surface of the pond on the upstream side about 30 deg. to an elevation of 6 or 8 ft. above the water on the downstream side. When a mass of ice strikes the breaker, it rides up on it, and the weight of the ice breaks up the mass. This takes away some of the destructive force of the moving ice field.

The next line of defense is the boom. This consists of sections of timber, either single logs chained together or more elaborate structures, more like a series of rafts chained together and anchored. The ice passing the breakers, as well as other floating débris, lodges against the boom and is deflected toward the spillway by the current.

Sometimes a second boom is installed a few feet out from the racks, which helps to hold ice and rubbish that has passed under the first boom. The racks are the inner line of defense. Their purpose is to screen all dirt and trash out of the water before it enters the turbines. Any ice that passes the booms and lodges in the racks has to be raked out.

Masonry Wall Sometimes Takes the Place of a Boom

In some installations a masonry wall with submerged arches is installed instead of a boom. This, while expensive, is the best method of protection from floating ice and débris, as most of it will remain at the surface and will be carried toward the spillway. If the intake through the submerged arches is at right angles to the river current, an ideal condition exists, and the plant will not be troubled with floating ice or trash.

A triangular opening cut in the ice back from the spillway is sometimes effective in turning the ice that way and keeping it away from the plant. The idea

is to make that portion of the ice field the weakest part, so that it will give way first in the direction of the spillway.

Unless the protection furnished the plant is unquestionably adequate and proved, if a large field of ice moves toward the plant, the safest thing is to shut down at once, causing a heavy current in the direction of the spillway, which should take the ice field with it. It would seem foolish to invite the onslaught of perhaps many thousand tons of ice on the intake and racks of a power plant. This is especially true when the plant is one of a group feeding into a transmission line, so that its load can be absorbed by the other plants. Probably the conditions are not exactly alike at any two plants, however, and it requires experience and good judgment to handle such a situation in the safest and best way.

Use of Dynamite Sometimes Necessary

The use of dynamite to break up ice is sometimes imperative. This should be handled with every precaution to prevent accident, and preferably by men accustomed to the use of explosives. Dynamite freezes at 40 deg. F. and explodes at 356 deg. F. It is necessary to thaw it if frozen, but this should never be done by placing it near an open fire. Keeping it in a warm place not exposed to anything that would tend to danger, or thawing it in a bucket set in hot water heated by steam or, if no steam is available, by removing the water from the fire before putting the dynamite in the bucket is the safest way to handle this explosive. It should not be stored in or near the plant, but kept in a small, remote building or, if the quantity is small, buried in a stout box.

Ice has a certain amount of resilience, and the greatest force of dynamite being downward, in some cases it will simply blow a hole through the ice without disturbing the surrounding area. Ice jams on which the open firing of dynamite had little effect have been broken by placing the dynamite in pieces of pipe capped on the ends. The explosion in this confined space being more violent and destructive than when fired in the open air and having a greater effective radius, greater precautions will have to be taken for protection from flying iron and ice.

Various power-plant organizations have developed ingenious and elaborate methods of handling ice. Others seem to have no special problem in this respect. If the pond is large and still, with little perceptible surface current, quite frequently the ice, once formed, will remain until it melts away. With the warm days of spring it will become honeycombed, will turn black, then will suddenly disappear. This is the best condition for the hydro-electric plant.

Formation of Anchor Ice

When the water becomes chilled at the beginning of winter, ice begins to form in minute invisible crystals, which in still water rapidly unite to form a continuous sheet of ice. When the water is churned and agitated in rifts and rapids, this union does not take place readily, but the crystals are distributed through the water at a temperature so close to the freezing point that a slight lowering of the temperature will cause them to solidify. Experiments carried out on the St. Lawrence some years ago indicated a difference of 0.003 deg. C. between a state of "ice" and "not ice." It would appear, therefore, that one form or degree of "anchor ice" is this crystalline formation at the critical temperature. When it touches any solid the slight remainder of heat above the freezing point passes into the solid, and the ice crystals "set," adhering to the solid body with which they are in contact. If this is metal, the effect is immediate, and the spaces between rack bars, turbine guides, gates and blades become quickly clogged up with the rapidly augmenting ice formation.

Some of these ice crystals touch and adhere to the river bottom and rapidly form a mass of spongy slush, which becomes buoyant, breaks away from the bottom and is carried downstream in a "syrupy" mass under water or in mushy clusters of "frazil" on the surface. This likewise adheres to the ironwork and generally finishes the job by piling up a mass of ice three or four feet thick in front of the racks.

When the pond or canal is once completely frozen over, trouble from this source is generally at an end. Ice crystals continue to form, but only in the immediate vicinity of the ice sheet, to which they adhere, increasing the thickness of the ice; there is rarely any further interference with the plant operation, unless by reason of the "January thaw" or other unseasonably mild weather there is a premature breakup of the ice sheet, exposing the water again to the conditions favorable to anchor-ice formation.

How Local Conditions Affect Method of Handling Anchor Ice

The best method of handling anchor ice must depend on local conditions. If there are a number of interconnected plants and one of them has trouble from this cause, if there is sufficient reserve capacity to carry the load, it is best to shut down. As soon as the anchor ice begins to run, see that the turbine gates are closed tight, and wait until the sun takes hold of the situation in the morning, when the anchor ice will in most cases disappear or will be so softened that it can be worked through the wheels. On the other hand, if a shutdown means impairment or interruption of service, strenuous efforts are necessary to keep going.

In one large plant that has considerable anchor-ice trouble, it has been found that a rope or chain hung in the pond and examined from time to time will give a good indication when anchor ice has begun to form, permitting proper measures to be taken to combat it. If ice forms on the chain, or if there are little needles of ice on the loose fibers of the rope, it is a good indication of a run of anchor ice that may give trouble.

Energetic raking of the racks will sometimes prevent them from filling up. Often it is necessary to have a sufficient number of men so that the whole length of the racks may be raked continuously. Some plants are equipped with two sets of racks, one with 6-in. spacing, to keep large objects from entering the wheelpit or penstock; the other, the regular close spacing. The latter are removed at the first sign of anchor ice, eliminating this part of the trouble, but the turbine gates are liable to become clogged up, especially if there is much "frazil" running, in which case it is difficult to avoid a shutdown. In several large plants it is the custom to keep one or more units off the line, and as soon as a unit starts to "plug up" one of the spare machines is put on in its place. The headgates are closed and the ice is removed by digging and steaming it out. This unit is then held to replace any other that may get into trouble.

A number of plants with which the writer has been connected have never had trouble from anchor ice. Each of these plants had a large pond with little perceptible surface current, so that the ice sheet was permanently formed for the winter generally in the first cold snap of the season, but the principal reason for their immunity was the absence of swift water within two or three miles of the intake. On the other hand, developments with a small shallow pond and with swift water near the intake could be depended on to give trouble from the first, still, cold, moonlight night until the pond was entirely frozen over.

Operating Under Low-Water Conditions

The spring run-off having subsided and much of the normal rainfall being absorbed by the soil and growing vegetation, the stream flow on most inland rivers is at its minimum during July and August. Sometimes this condition occurs in the winter, when by reason of a prolonged spell of intense cold the thousands of little rivulets and springs that feed the river freeze up, thus greatly lessening the flow.

During the period of low water, hydraulic efficiency and economy, which are of secondary importance when a large amount of water is passing over the spillway, must be rigidly practiced. In many cases it is necessary to pass the natural flow of the stream to permit continuous operation of industries downstream. The plant must be kept in continuous operation even if there is insufficient water to operate at an efficient gate opening. But where the plant is able to do so, it should be operated at the gate opening that gives the highest efficiency, between 0.7 and 0.8 of full opening, even if it cannot be operated in this way more than two or three hours a day.

On some of the streams with which the writer is acquainted a 10-hour load is carried, with a little loss of head each day; then, at the end of the week, the Sunday shutdown will permit the pond to fill again by the time the load comes on Monday morning. Running at efficient gate opening part time and then shutting down to let the pond fill, is possible only when the plant is connected with other plants that can carry the load through a transmission line and where the shutting off of the natural flow of the stream will not interfere with the rights of those who may depend upon water power downstream.

Predicting Stream Flow in Low-Water Conditions

In low-water conditions careful prediction of stream flow is essential to hydraulic efficiency. If the plant is connected with others and the operator or dispatcher knows in advance how much water he may expect, he can gage the load accordingly. The load should be maintained as uniform as possible, as an unsteady load will result in an inefficient gate opening most of the time. Usually, this may be accomplished by governor adjustment without locking the gates. The governor may be set to operate more sluggishly than the steam or other prime movers on the system, so that at ordinary frequencies the load will not change, while at abnormal frequencies load will be picked up or dropped until the speed is normal again, when the unit will take its predetermined load with little variation.

The use of hydro-electric units as synchronous condensers comes properly under the head of electrical operation, but may be mentioned here as it has a bearing on hydraulic efficiency. The modern vertical unit may often be used for this purpose without hydraulic waste by bringing it up to speed with the turbine; then, after it is synchronized on the line, shutting off the water entirely, breaking the vacuum in the draft tube and letting it motor on the line. If the vacuum is not broken, the machine will take a considerable amount of power which is wasted in churning the water in the draft tube. This use of the vertical unit is possible by reason of the absence of bearings under water, the weight of the revolving parts of the machine being carried on the thrust bearing on top of the generator.

If it is desired to make use of the older style of horizontal unit for this purpose, enough water has to be utilized to keep it up to speed, usually about 0.2 gate opening. This is a direct loss, and the use of horizontal units for power-factor correction should be avoided when there is load for all the water flowing in the stream.

Stopping Leaks at the Dam

All leaks in dam, waste gates and flashboards should be carefully stopped when the water gets down so it is not necessary to spill. The gates should, of course, be tight shut, but even the best gates will leak a little, so it is necessary to pack them. Probably the best material available for this purpose is ordinary soft-coal cinders. This material sifted down the joints of the gates will work into every small opening and generally stop the leaks. If the leak is so large that cinders will wash through, a bag of cinders or sand may be used. On the joints of tainter gates a willow pole, cut wedge-shaped on one side, may be driven into the joint by bending to the curve of the gate. The coarse burlap from cotton bales, or any burlap, will be found effective. Sometimes, in case of a large leak a discarded mattress will be found to fill the requirement. These methods are cited merely as instances of what may be done to stop these expensive leaks. The ingenious operator can probably think of many more ideas as effective as these.

Putting on Flashboards

In putting on flashboards, the pond should be drawn down a little so the crest of the dam will be dry for the safety and convenience of the men. Flashboards are not hard to put on, but sometimes it is difficult to prevent them from leaking. Cinders will wash out, owing to the irregularities of the crest and the wash of the waves. A narrow board blocked out upstream from the flashboards with pieces of 2 x 4-in. timber will help hold the packing materials in place.

During the low-water period in summer there is generally considerable trouble from lightning, which introduces a problem. If the plant handles directly a local load of any size, the head should be kept up, so that in case of trouble on the transmission line, the local load can be handled without lowering the head too much. On the other hand, a transmission-line failure may necessitate spilling where there is no local load. It would seem wise to keep the head down a little where there is no local load to hold the water and to keep it well up where such a load must be carried.

In handling the river, the main effort in low water is to pass the entire flow of the stream through the turbines at an efficient head and efficient gate opening.

Evaporation—Its Calculation and Relation to Boiler Efficiency

By Allen F. Brewer

To measure most effectively water and oil fuel, meters are generally used, of either the rotary or piston type for the oil, and the venturi, V-notch, or one of the aforesaid for the water. Unfortunately, however, the management of many oil-burning installations have failed to see the importance of records, etc. And hence, meters, particularly for the oil, have been disregarded and omitted from the plant equipment as non-essential. If an approximate idea of the amount of oil consumed is desired, they will say that gaging the storage tank will be good enough. True, if carefully made this is an excellent means of measuring, but the bad feature is that there is considerable personal error involved, due to chance of slack tape, not gaging from the same point each time and allowing the oil (if light) to run down the tape before reading. Therefore, the oil meter takes preference in the modern plant, even though an allowable error of one per cent is customary in most makers' guarantees.

Obtaining Evaporation Without Meters

But in the plant where there are no meters, even gaging the oil tank will still leave us with the amount of boiler-feed water as an unknown quantity; hence, to arrive at an approximate figure for evaporation we must resort to computation based on the average heat content of the oil fired, the feed water at 212 deg. F. and the normal boiler efficiency that should be developed. The most usual grades of oil fuel today will range from heavy Mexican crudes of 11 deg. Baumé gravity, to the lighter distillate and residuum fuel oils of gravity up to 18 deg. Baumé. Above 18 deg. Baumé the smaller plant will seldom get a fuel oil, owing to its excessive cost and the inability of the marketers to contract for specified deliveries. More and more are lighter fuels giving way to the heavier grades because of more improved refinery methods which utilize the former for re-running processes and lubricants, etc. True, most naval specifications call for an oil of between 21 deg. and 23 deg. Baumé gravity, but such a fuel is practically beyond the reach of stationary boiler operators owing to long-term contracts and scarcity.

Therefore, assuming that the average plant is firing an oil fuel of say 14 deg. gravity, we will have a constant heat content of approximately 18,500 B.t.u. per lb. One pound of water vaporized to steam from and at 212 deg. F. will contain 970.4 B.t.u. Hence, the theoretical evaporation, in pounds of water per pound of oil fired, would be,

$$\frac{\textit{B.t.u. per lb. oil}}{\textit{B.t.u. per lb. water f. and a. 212 deg.}} = \frac{18{,}500}{970.4} = 19.06$$

Such an evaporation is based on 100 per cent boiler efficiency, but inasmuch as the normal plant will seldom develop an average efficiency above 80 per cent, this figure may be taken as a constant for our problem, and the theoretical evaporation multiplied thereby; that is, 19.06 (theoretical evap.) $\times$ 80 per cent $=$ 15.25, or the actual evaporation from and at 212 deg. F.

To proceed farther to a typical case, if one pound of oil will evaporate 15.25 lb. of water from and at 212 deg. F., we may desire to determine the actual pounds of water evaporated at the steam pressure carried, taking into consideration the temperature of the feed water. Let us assume the steam pressure at gage to be 150 lb. and the temperature of the feed water to be 150 deg. F. The total heat of steam at 150 lb. gage is 1,195 B.t.u. From this must be subtracted the feed-water temperature, 150 deg., to arrive at the net total heat per pound imparted in raising the water to steam at 150 lb. pressure, or 1,195 — 150 = 1,045 B.t.u.

The total heat of steam at 212 deg. F. is 1,150.4 B.t.u., from which we must deduct the total sensible heat of the water above 32 deg. F.—that is, 180 B.t.u.—to arrive at the latent heat of the steam at 212 deg., or 1,150.4 — 180.0 = 970.4 B.t.u.

Therefore, to convert the rate of evaporation—that is, 15.25 lb.—from conditions existing from and at 212 deg. F. to the conditions under which the water is actually being evaporated, 150 lb. gage pressure and 150 deg. feed water, it becomes necessary to use the following formula:

$$\left.\begin{matrix}\textit{Evap. from}\\ \textit{and}\\ \textit{at 212 deg.}\end{matrix}\right\} \times \left\{\begin{matrix}\textit{Latent heat of steam at 212 deg.}\\ \hline \textit{Total heat of steam at gage pressure}\\ \textit{minus temperature of feed water,}\end{matrix}\right\} =$$

actual evaporation under the foregoing conditions, or, 15.25 $\times$ 970.4 $\div$ 1,045 = 14.15.

Operating Efficiency Should be Known

Of course the argument may be advanced that the calculations given are based on a comparatively high theoretical efficiency, and whether the plant may develop this constantly is a doubtful question. Very true, and in view of this fact the engineer should, if possible, determine a value for his boiler efficiency by a several hours' run, measuring water and oil consumed by use of small auxiliary tanks. On the other hand, if a recent plant test has been run, the efficiency obtained therefrom can be used instead, as it should prove the boiler's capability under actual operating conditions.

To calculate boiler efficiency with such data at hand, we need only to know the equivalent evaporation per pound of fuel, which can be obtained directly from our measured quantities of oil and water (the latter being corrected by the factor of evaporation for the steam pressure and feed temperatures) and the B.t.u. content of the oil, which, in lieu of actual test, can be safely assumed at 18,500. Then using the formula,

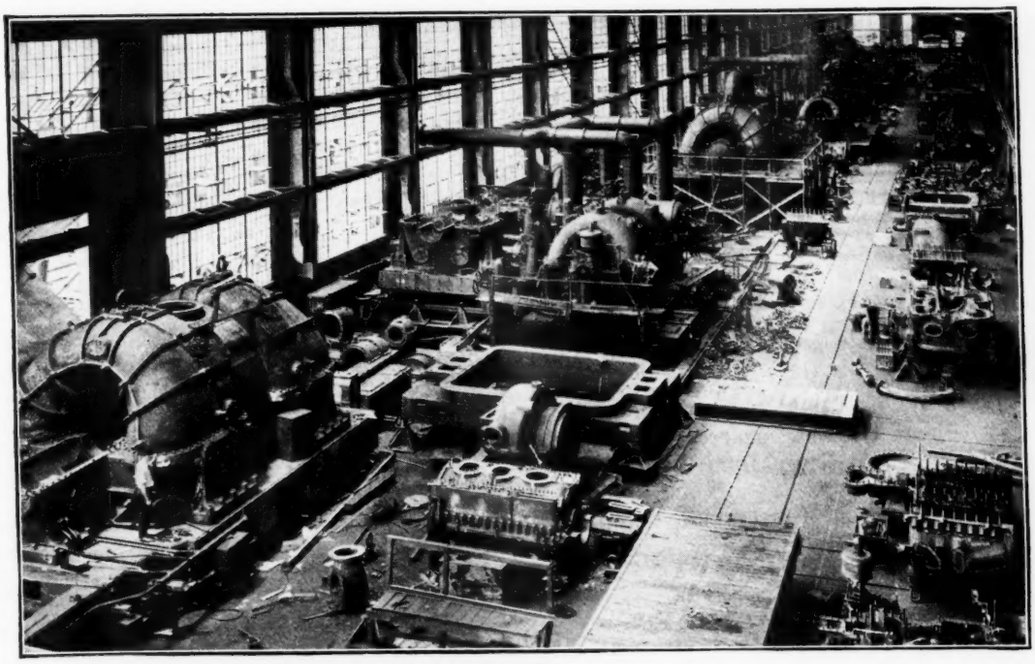
$$\textit{Efficiency} = \frac{\textit{Equiv. evap.} \times 970.4}{\textit{B.t.u. content per lb. oil}}$$

or, if our evaporation showed up as 15, we would have

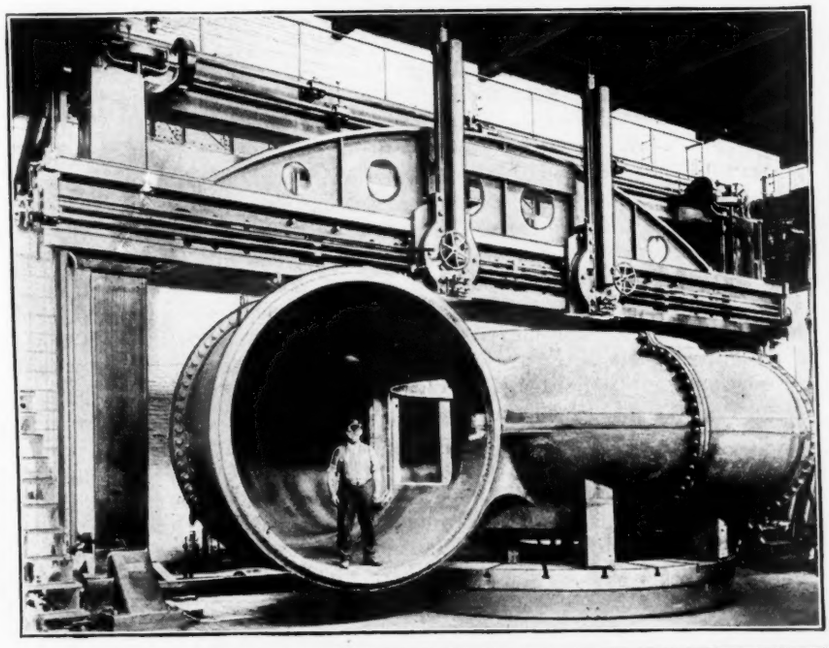
$$\textit{Efficiency} = \frac{15 \times 970.4 \times 100}{18{,}500} = 78\ 68\ \textit{per cent.}$$

The amount of stuff that is not steam which goes through a steam main is surprising even with superheated steam. Mud and scale-forming material are frequently carried through and plastered upon the blades of turbines, and frequently pieces of packing, nuts, bolts and even larger and heavier objects are carried to surprising distances through the piping systems. Strainers put into the steam main may under certain operating conditions without periodic inspection, defeat the very purposes for which they were used, as they themselves may go to pieces and be carried into the blades.

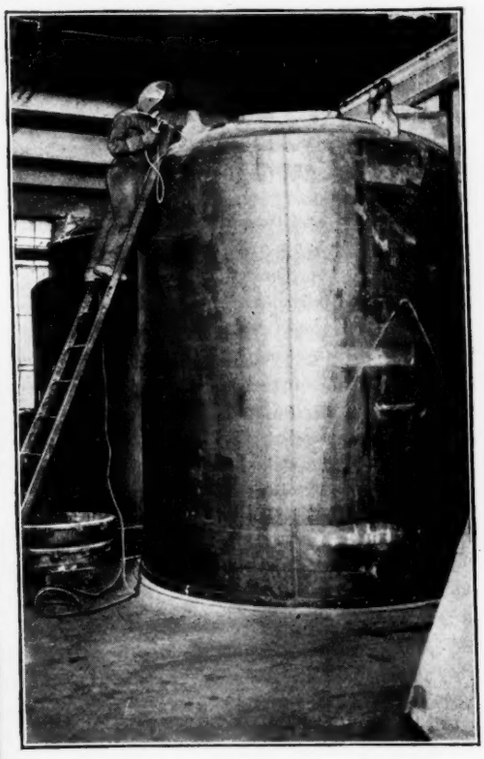
No business depression here! "Business as usual" seems the order in the testing room of a prominent manufacturer shown on the right. This room is taxed to capacity with big steam turbines, including two 35,000-kw. units, three 25,000-kw. and several smaller ones. The combined capacity of all the machines in the picture is 169,000 kw.

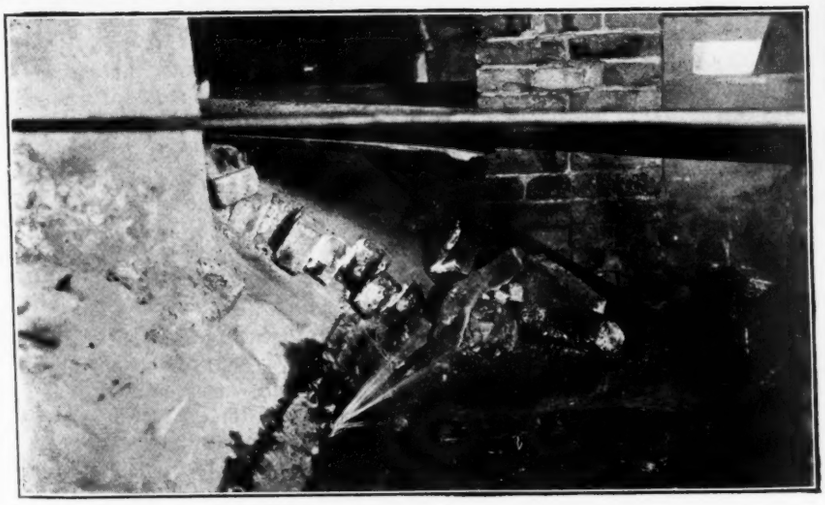


Below is shown a 17,000-hp. hydraulic turbine scroll case being machined on a boring mill that is believed to be the largest in the country, except for one that is one foot wider. This mill, which takes work up to 35 ft. dia. by 14 ft. high, is used by the S. Morgan Smith Co. in building big power machinery. The scroll case shown weighs 86 tons and has a 10-ft. dia. intake. The unit will operate under a head of 135 ft. at 171.4 r.p.m.



The photograph below is the first one taken of the tanks for what is planned to be the largest oil circuit breaker in the world. It is being built by the G. E. Co. at Schenectady for the 220,000-volt transmission line of the Southern California Edison Co. Note the application of electric welding.





At the left, a disastrous boiler explosion in the making, which was prevented by an inspector's timely investigation. This is an excellent example of the dangerous lap seam crack. Note that the boiler covering prevented the steam that must have leaked through the crack from being seen by the engineer. The inspector, however, having noticed brown stains on the boiler while inside the furnace, removed the covering where he thought the trouble was and filled the boiler with water under pressure, with the result shown.

Courtesy of The Locomotive, Hartford Steam Boiler I. & I. Co.

Industrial Power Plant Improved

By Douglas Henderson

Situated in Northern New Jersey is the plant of a metal-can manufacturing company, and the story of its power-plant achievements during the last two years is one of intense interest. It brings out forcibly what can be accomplished, provided a little executive attention is permitted to stray in the direction of the boiler room. The power plant was designed carefully some years ago, with the idea of installing proper equipment. It contains three return-tubular boilers. They are hand-fired and a shaking type of grate is used. The products of combustion are taken from the boilers through a steel flue and discharged into a brick stack 135 ft. tall and about five or six feet in diameter at the top.

There are two 16 x 30-in. Corliss engines installed, each driving a 150-kw. generator. The mill machinery is all electrically driven from these generators. Under average load conditions only one unit is required, but occasionally a peak demand will cause both machines to be placed in service.

The night lighting load is taken care of by a 10-kw. generator, driven by an 8 x 6-in. vertical engine. The night load of the mill is rather small, which means a low load factor. The day load of 10 hours is considerably heavier than the night load, which is 14 hours in duration. In addition to the apparatus mentioned, there is the usual number of pumps—boiler feed, etc.

The exhaust steam from the engines is turned into a low-pressure main which is carried about the plant and supplies steam to the heating system. The returns from the heating system are brought back to the plant by means of a vacuum pump and delivered to a storage tank from which they are fed by gravity to an open feed-water heater. Two years ago this plant was burning No. 1 buckwheat under natural draft and during the winter all three boilers were used to carry the load. No particular difficulty was encountered, and to all appearances the results obtained were as good as could be expected. Apparently, there was no reason to suspect that coal was being burned uneconomically, and everyone was content to go along without change.

Just about that time the president of the company interested himself sufficiently one day to wonder how things really were going in the power plant and developed a curiosity strong enough to authorize a survey to be made of that department to determine what actual results were being obtained, and if they could be improved upon to reduce the coal bill, recommendations to that effect were to be carried out.

The investigation disclosed in the first place that although overall efficiencies fell between 60 and 70 per cent, there was an excessive loss of coal through the grates, which was proved by the large percentages of unburned carbon in the ashes. This, of course, might be expected from the combination of burning No. 1 buckwheat under natural draft.

It was soon learned that the boilers were being operated at about 40 per cent of the builder's rating and the trouble was directly traceable to insufficient draft. The first thing, then, to improve conditions was to remedy the draft shortage, and in this connection a forced-draft installation was considered. There having been air ducts built in the bridge walls of the furnaces, and since a common duct had been previously built, connecting the branches, it was deemed best to install a forced-draft fan, with engine drive, in a separate building adjacent to the boiler room, and to connect the main duct already in place to one leading to the fan discharge. The plan was adopted and an effort was made to obtain the proper equipment without too much delay.

A second-hand multivane fan was located near New York of practically the dimensions previously determined upon for the new one, and a second-hand vertical engine, exactly what was needed as a prime mover, was next found, and in considerably less time than would have been required to deliver a new unit the apparatus was in place ready to be put into operation.

Simultaneously with the introduction of forced draft, the fuel was changed from No. 1 buckwheat to a 50-50 mixture of Nos. 2 and 3 buckwheat. It was a rather radical move, but considering the personnel of the power plant, it was a chance well worth taking. Subsequent investigation checked that, for satisfactory operating results were obtained at a decided reduction in coal cost.

After the new plant had been in operation in the boiler room for several months, it was decided to get some comparison between the old and the new conditions. For this purpose the operation extending over the period of one month was selected as the unit for comparing, and the month of April, 1920, was used against April, 1921. A month's operation would give a valuable average, for it would be affected by all kinds of influences, such as load, personnel and fuel.

Taking into consideration the fact that, owing to business conditions, the plant load was much less during April, 1921, than during the same month last year, nevertheless the cost of evaporation per 10 sq.ft. of boiler heating surface in April, 1921, was $0.0104 as against $0.01158 the year previous. This includes only the fuel cost, as labor and other charges remained practically the same. The plant now operates on two boilers during the day load, and during the night and Sunday one boiler is sufficient. There are many days when one boiler will supply all the steam requirements, but for emergency purposes the other boiler stands by. On the basis of the present steam demand the saving represented approximates $7 a day which will soon pay for the change.

In order to assure continuous supervision of the boiler plant hereafter, some essential instruments were procured. A CO_2 recorder was purchased for each boiler; a recording pyrometer, with a thermocouple in the uptake of each boiler, giving valuable information regarding internal boiler condition. Indicating draft gages for the firemen were placed on each boiler, showing simultaneously the draft in the ashpit, in the furnace and in the uptake. The firemen have been instructed in the use of these instruments, and their revised efforts have already shown gratifying results. A steam-flow meter now gives instantaneous indication of the steam demand in the factory, and this information has been of great assistance in running down losses of steam in that location.

Information is accumulated daily from the instruments installed, and this data is worked up into a monthly statement showing at a glance the operation of the power plant for that length of time. In this way the difficulties are picked up and remedied before they develop into serious financial losses.

The story of this plant is interesting because it is typical of the average American industry in size, but considerably above the average in power-plant operation; in spite of that it was possible to make a reduction in the coal bill. Think of the possibilities in the average plant.

EDITORIALS

Power Plants at Coal Mines

MUCH has been said within the last few years regarding the location of power plants at coal mines and transmitting the power to distant points, the impression being given that this will be the method employed in the future, thus relieving our large cities to a degree of the smoke and cinder nuisance to which they are now subjected. From the hygienic standpoint this is very desirable and little can be said against the proposition. But when examined from the economic angle there are many factors that operate against the complete realization of this project. It is now generally realized that the locations at the mines where large power stations can be constructed such as would be required in any superpower scheme are limited. There are many sites where such plants can be built on the large rivers, but these are some distance away from the mines, which means that the coal must be transported over main-line railways. After coal has been loaded on standard railway cars the difference in freight charge for transportation all the way to where large demands for power are required and part way make it desirable to use the long haul, at least as a dollar and cents proposition. Long high-voltage transmission systems are expensive to construct and maintain, also transmission and tranforming losses average around ten to fifteen per cent and in some cases even higher. Furthermore, overhead transmission systems have not reached the high degree of reliability that underground transmission and distribution systems have.

The leading article in this issue describes the Seward power-plant of the Penn. Public Service Corporation. This plant is located only about six hundred feet from the mouth of a coal mine. In this installation to obtain sufficient condensing water to develop one hundred thousand kilowatts it will be necessary to build a dam across the river below the plant and recirculate the water. On account of the sulphuric acid in the water, which is typical of conditions found around the mines, it was decided to use jet condensers. Although this type of plant may be the most economical for the locality it serves, nevertheless, it is far from meeting the standard established for a superpower station from which energy is to be transmitted long distances. If the territory to be served by Seward station had been located on some river that could supply abundance of good circulating water, forty or fifty miles away from the mine, it would undoubtedly have been found more economical to build the plant in that location and transport the coal, than to build the plant at the mine and transmit the power electrically.

When demands for the electrification of the railways throughout the mining districts such as are found in Pennsylvania and the increase in power requirements by industries in these regions are taken care of by mine-mouth stations there probably will be few available sites left on which to construct superpower stations for long-distance transmission of power to large seacoast cities. However, this does not prevent the power system in these regions being tied in with those of other districts to obtain a more economical distribution and to enable one system to give assistance to another in case of trouble, which, after all, is one of the most important factors in favor of interconnected power systems.

Small Plant Losses

IF AN ENGINEER feels any pride in his work the neat appearance of the engine room will impress the plant visitor. Many men have been promoted to higher positions as a direct result of the apparent cleanliness of the plants under their care, on the assumption that this indicated an efficient plant. While no one will gainsay that neatness is of advantage and praiseworthy those who are at all familiar with the subject know that mere neatness and a shining engine are not proofs of the economy secured. The careful up-to-date engineer will not stop this work when the wiping job is completed but will look for those small but constant losses which may destroy all the economical effects of the labor in the engine room.

What, for example, do you know about the condition of the steam traps? Are the valves tight or is live steam being wasted into the sewer? For that matter what are you doing with the trap returns? A lot of plants are throwing this heat into the sewer. Connect up the trap returns to the feed-water heater. How about the method of firing followed in the boiler room? Does the fireman open the firedoor a trifle when the pop valve blows or does he increase the flow of feed water to absorb the excess heat of the furnace? Does he blow down often to get rid of the high water level or does he regulate the feed water to suit the load conditions? How much coal do you waste in the ash pit? Have you examined the furnace walls lately and carefully noted their condition?

If you are running the engine with saturated steam have you ever figured the loss due to exposed steam piping or the effect of water entering the cylinder for the lack of a suitable separator? Simply because the valves of the Corliss or high speed engines do not groan do you assume they are leak-proof? An indicator is a good instrument to use on engines and pumps. Have you one—is it in the upper shelf forgotten or do you take indicator diagrams once a week and then study them to see if the adjustments are what they should be to give best results?

These are but a few of the items that should not be overlooked. In many plants the chief factor which has prompted the replacement of the plant by central service is not the efficiency of the prime movers, but the countless small losses which are too often overlooked even in fairly modern plants.

Study for the Practical Man

IN DISCUSSING a subject such as this the most one can hope to do is to point out certain principles that are true in the majority of cases, leaving the reader to make his own exceptions. With this in mind it is safe to proceed with a few observations in regard to the relation of study to the success of the practical power-plant man.

Sometimes the man whose training has been entirely in the school of hard knocks feels a little envious of the technical graduate to whom knowledge has been "handed on a platter." How far *he* would travel with such an opportunity!

On the other hand, the young man just out of a technical school, has, if he is gifted with common sense, a deep respect for the practical man who handles the thousand and one problems of his daily work with such confidence and skill. He sees that practical experience is essential to success, so he jumps at the chance to put on overalls and take a course in the school whose diploma is the horny hand. He does this not only because he realizes that such knowledge is quite as important as that obtained from books—and probably more so—but also because he feels that he will never be entirely self-respecting and happy until he can skillfully handle, with his own nerves and muscles, those forces that he has known chiefly as mental pictures. If he learns these practical things as well as he has presumably learned what his text books and teachers had to offer, he has taken a long step toward real success.

How about the other fellow—the man that left school early and has since worked for his living at practical tasks? Must he let the young technical graduate—the fellow with the bright ideas and the unskilled hands—outdistance him in the race for promotion? The true sportsman says, "Let the best man win," but he makes sure, if it is humanly possible, that *he* is the best man. Just as in true sport, nothing unfair, no lack of give and take, is implied by this spirit of competition. It means simply that a man gives others full opportunity to do their best and then trys to "go them all one better" by being the best trained and the most consistently on the job.

Instructors and college routine render the greatest service to the student in compelling him to study. Of the many men that have a desire for the benefits of technical knowledge not one in ten has sufficient perseverance to start an adequate course of study and see it through to the finish unless there is a "whip" over his head most of the time. The technical school, by a system of rewards and penalties, and occasionally by coating the bitter pill with chocolate, induces the average patient to take his daily medicine. Yet, if the home student has the requisite dogged determination he can be his own taskmaster and reap the full reward of steady, concentrated effort.

The other function of the technical school is to guide the student in his work by deciding what subjects and parts of subjects he shall take up and what proportion of his time he shall give to each. Unguided study often means misdirected energy because too much time is spent on non-essentials. Fortunately the home student in these days can have intelligent guidance by following some carefully planned course of study prepared by men who have the necessary teaching ability.

It is unfortunately true that the average man who starts such a course seldom finishes it. In most cases this is not because he lacks ability, but because he has not sufficient power of will to keep pegging away at the big task until it is finished. The exceptional man who does see it through not only acquires a wonderful combination of practical and technical knowledge but also proves that he is master of himself. Such a man is bound to rise head and shoulders above his fellows.

An Opportunity for Marine Engineers

IN THIS ISSUE is a short account of the free marine turbine courses now being offered by the Government through four well-known educational institutions. The courses are open to holders of Federal licenses as marine engineers, and are intended to provide the training that such men need to fit them to become turbine operators aboard ship.

The fact that these courses are being offered free and the character of the institutions where they are given affords an opportunity not to be neglected by marine engineers that lack the qualifications required of turbine operators.

It should be remembered in this connection that the trend in prime mover design, on sea as on land, is now and has been for several years away from the reciprocating engine and toward the less bulky turbine. While reciprocating steam engines are undoubtedly being built in quantity, the lead of the turbine over the older type of machine is becoming greater rather than less. The development of electric drive for marine propulsion will have a further effect in this direction.

The man that can run turbines as well as engines will be likely to find better jobs and to find them more easily than if he lacked that ability; and it may well be added here that this suggestion holds equally true for stationary power-plant engineers.

Still Room for Expansion

THE super-power zone, representing about two per cent of the area and 22 per cent of the population of the United States, is reported by the Bureau of the Census to include an aggregate of equipment installed for manufacturing establishments of over nine million horsepower. Of this, two-thirds represents prime movers and one-third purchased power. The six million horsepower of prime movers at these manufacturing establishments in the super-power zone account for approximately one-third of the entire primary horsepower capacity of the country in manufacturing industries. Thus two per cent of the area includes over thirty per cent of the power facilities.

If the rest of the United States was correspondingly active in industrial affairs it would mean a total of nearly half a billion horsepower in manufacturing establishments. Of course, no one would expect that all of the United States will ever become as concentrated in industrial activity as this zone, for it is essential that there be large agricultural territories in which to grow foodstuffs. However, there is plenty of room for growth in the rest of the country, for even in this best developed region the elimination of manual labor by substituting power-driven labor-saving devices still has much to accomplish.

CORRESPONDENCE

Moisture in Pulverized Coal

The writer refers to the abstract on page 762 of the May 10 number of L. L. Hebberd's paper on "The Drying of Pulverized Coal," in which he indicates the feasibility of getting along without driers in a pulverizing plant; and to H. G. Barnhurst's reply on page 71 of the July 12 issue. Mr. Barnhurst listed some of the advantages gained by drying and showed that the instances cited by Mr. Hebberd of plants where driers are not used cannot be considered as typical of general practice.

Under the difficulties in handling and distribution caused by moisture, we might add that moisture is one of the chief accelerators in spontaneous heating. Experimental work performed by the writer confirmed the recommendations of many manufacturers of pulverizing machinery, that the coal be as dry as possible to give the best results in pulverizing and burning. Typical samples of crushed bituminous coal, lignite, and peat were each subdivided into portions differing only in moisture content. Each portion was given a certain amount of pulverizing in the same mill, and the percentage product passing through a 200-mesh screen was then measured. With both Pittsburgh and Kentucky bituminous the most advantageous moisture content for pulverizing was about 1 per cent; below that nothing was gained, while above that the cost of pulverizing rose rapidly with increasing moisture content. In the case of Illinois bituminous having a much wider range of moisture content, 1.8 per cent to 2 per cent seemed to be the most economical moisture content. If the coal is dried more than this it evidently becomes harder, because the cost of pulverizing goes up. If the moisture content is above this point, the pulverizing cost rises rapidly with increasing moisture. The most economical moisure content for North Dakota lignite was found to be in the neighborhood of 7.5 per cent, and for peat about 9.5 to 10 per cent. Above these figures, pulverizing costs increased rapidly.

Another factor affects the extent to which drying can be economically carried. The major portion of the moisture content of any fuel seems to be surface, or free moisture, while the small remainder might be called inherent moisture. The former is easily driven off, the latter with difficulty. For instance, any drying of lignite on a commercial scale below 5 or 6 per cent is quite expensive, indicating that before this point is reached, the free moisture has all been driven off and a start has been made on the more obstinate inherent moisture. The work seemed to indicate that in each case the most economical moisture content for pulverizing was also the point beyond which drying itself becomes disproportionately expensive.

A word as to fineness. The work at the Lakeside plant at Milwaukee has shown that the time-honored figure of 80 to 85 per cent through a 200-mesh screen necessary for good combustion is too high, and that it is much more important that the combustion chamber be properly designed than that the fineness should be so high. The fineness necessary depends largely on the specific gravity of the fuel. When the fuel is lighter, larger particles can be carried along in the air current, and when the specific gravity is higher, the particles must be smaller.

We found the following percentages through a 200-mesh screen advisable for different ranks of fuel: Peat, 50-60 per cent; lignite, 65-70 per cent; bituminous, 73-80 per cent, and anthracite, 80-86 per cent.

Philadelphia, Pa. W. J. RISLEY, JR.

Operating Compound Generators in Parallel

Concerning the article, "Parallel Operation of Compound Generators," Mar. 22, and subsequent letter of comment by James M. Kent, published in the July 5 issue, the discussion centers on the arrangement of switches and the sequence of closing the armature, series field and equalizer switches of a two-wire direct-current generator when operated in parallel with another similar unit. There are several common switch arrangements. Perhaps the most common practice with small generators is to install a three-pole switch, the two outer blades being fused. The central blade, unfused, is the equalizer. In this case all three lines are closed simultaneously.

Another arrangement, used with the smaller units particularly, includes a two-pole knife switch for the series field and equalizer leads and a circuit breaker for the armature lead. This minimizes equipment and cost, yet provides a circuit breaker. This arrangement is operated by closing the circuit breaker first and the two-pole knife switch second, in line with Mr. Kent's contention.

For the larger units the switches become too large for manual operation in multiple arrangement and single-pole switches are used. In operating, the equalizer should be closed first, then the series field and armature switches in sequence.

It is preferable to close the switches on the series-field side first, placing this field in parallel with the

field of the generators in service. The voltage of the incoming machine may then be adjusted, if desired, and the switch in the armature circuit then closed. This practice gives minimum disturbances and insures correct polarity to the incoming unit. Ordinarily, there is but a short time interval between closure of the series-field switch and the armature switch. In the case where single-pole switches are used, this procedure is necessary, since neither the equalizer nor the series-field switch should be closed singly after the armature switch is closed and their independent operation requires at least a short time interval.

Mr. Kent's criticism of the single-pole equalizer switch is correct, in that the operator must be depended upon to keep the equalizer closed. It is very common practice, however, to supply single-pole equalizer switches. Often they are located on separate pedestals near the machines in order to minimize the length of equalizer connections.

It may be mentioned that, for grounded systems, the equalizer switch is closed and the series-field lead connected to ground before the armature switch is closed, in accord with the practice herein recommended.

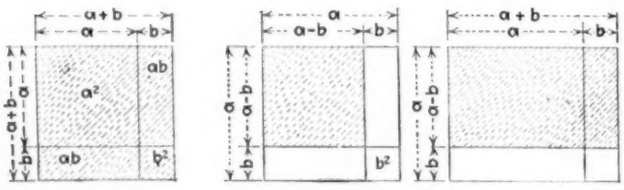
On grounded systems, with engine- or turbine-driven generators, a circuit breaker is required in the grounded series-field lead, in addition to the circuit breaker in the armature lead, in order to protect the machine from severe damage in case of an internal ground. Motor-driven generators need not be so protected if the driving motor is equipped with overload protection.

Chicago, Ill. GORDON FOX.

Humanizing Engineering Formulas

How often one hears the expression, Use your "common sense." Students are told that all the problem requires is the application of common sense, yet in many ways our methods of presenting formulations do not afford sufficient ground upon which to base good judgment. Formulas are the tools with which one must work, hence it is necessary not only that we know them, but also that we know how to use them. If properly presented, they should produce mental pictures, not memorized symbols.

Some subjects present more difficulties than others. Take some of the algebraic formulations, as $(a + b)^2$, how can it be proved that it is equal to $a^2 + 2ab + b^2$? Assume a and b to represent lines, their square makes an area, shown in the dotted cross-section, Fig. 1, from which can readily be seen each square and rectangle required by the algebraic result. Again $(a - b)^2 = a^2 - 2ab + b^2$. In Fig. 2 a^2 is the entire square, and the answer is that portion in dotted cross-section. If we subtract two rectangles ab, the portion b^2 has been deducted twice, and to give the correct result it must be added, as both rectangles overlap and it can be counted in one only.



FIGS. 1, 2 AND 3. ILLUSTRATING ALGEBRAIC FORMULA BY MEANS OF AREAS

The product of $(a + b) \times (a - b) = a^2 - b^2$, Fig. 3, and the dotted cross-section portion is the answer. First take away the lower rectangle ab. If we add this to the right-hand side, it is just b^2 too great, hence a^2 must be reduced by b^2 to give the shaded portion.

The cube of $(a + b)$ brings in the three dimensions and gives the solid, Fig. 4. This can be best demonstrated by use of a model. Beginning with the a^3, there are three square prisms a^2b placed on the three faces, next three square prisms ab^2 to fill in the corners, and finally completed by the b^3 in the lower right-hand corner, as shown. If $(a + b)$ is considered as a and b is subtracted from the same figure $(a - b)^3$ can readily be developed. These few illustrations may lead to others, and it presents a means of visualizing, which may be of assistance to many to whom the ordinary formulations mean little or nothing.

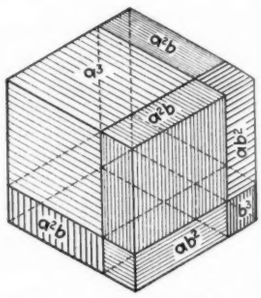


FIG. 4. BY MEANS OF A CUBE

New York City. CHARLES W. THOMAS.

Cooling Condensing Water

During the spring months, when the water used for condensing purposes is dirty, owing to high-water conditions of the source of supply, during the summer months, when the water is low, and during the fall months, when the water is filled with grass, leaves, etc., the condenser operator has his troubles with dirty condenser tubes.

Why would it not be possible to use the same condensing water over and over again, thus keeping it in a practically clear state, and cooling it by using an atmospheric type of condenser similar to that used with ammonia systems, but of the single-pipe construction?

With a 10,000-kw. turbine such an atmospheric condenser would require about 36,000 lin.ft. of 2-in. pipe to cool the condensing water from, say, 110 deg. to 80 deg. with 70-deg. cooling water. Of course this seems like considerable piping, but would not the saving made in the cost of cleaning condenser tubes offset the cost of the atmospheric condenser?

Boston, Mass. A. F. SPECHT.

Locating Water-Relief Valves

Since there is always the possibility of the boiler-room attendants closing one feed valve before opening another, thus having all valves closed at the same time while the feed pump is running, the use of a relief valve on the feed line is desirable, but its successful operation depends very much on its location. In Fig. 1 are shown two pumps with a horizontal closed heater having two stop valves A, a bypass valve B and a water meter between the valves C. D is a 4-in. relief valve placed near the heater, and near the standpipe at the end of the 4-in. feed-water main is another 4-in. relief valve E. The pumps were installed in parallel, with a stop valve F between each pump and the discharge main.

The fireman was to have changed pumps one night, but in the morning a gasket was found blown out. How

it happened no one knew, but it was supposed that the fireman forgot to open the discharge valve on No. 2 pump.

One day the relief valve *D* was found to be leaking. A watch engineer tightened it up and stopped the leak. Later on the two engines that were exhausting through

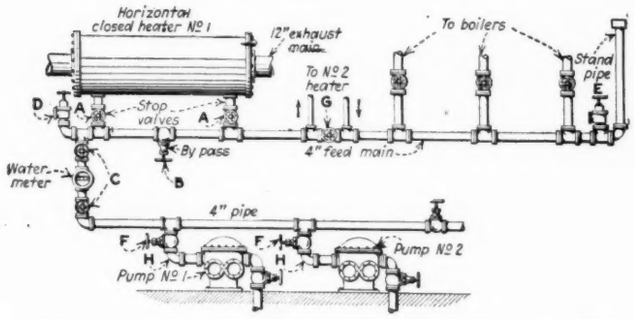


FIG. 1. PIPING FOR TWO PUMPS AND TWO HEATERS WITH RELIEF VALVES

No. 1 heater were shut down and the orders were to shut off the stop valves *A* and open the bypass valve *B* (which was done) and use No. 2 heater, not shown. When the time came to start the engines in the late afternoon, a man was sent to change back to No. 1 heater. Instead of putting the heater on the line and opening the valve *G*, he closed the inlet valve on No. 2 heater first, and the gasket was blown out of a flange near the stop valve *F* of the pump that was running. The fireman stopped the pump and tried to start the other one, at the same time sending the coal passer after the chief engineer.

Upon the chief's arrival he found the man leisurely opening the outlet valve on No. 1 heater with the inlet valve and the valve *G* closed.

When the chief examined the relief valve *D*, he found that it was set down solid. It was readjusted and allowed to leak until it could be shut off long enough to regrind. Examination of the relief valve *E* showed that someone had plugged the outlet.

The two relief valves were put in good order and set at 140 lb., or 15 lb. above the boiler pressure, and a 2-in. relief valve was put on the discharge of each pump at *H*. Pressure gages were also connected to the discharge chamber of each pump, and they were a great aid in changing pumps without stopping the flow of the feed water to the boilers. I hold that the 2-in. relief valves should have been substituted for the 4-in. valves *D* and *E* and the latter valves placed at the pumps, so as to take care of the pressure in case of the sudden closing of the discharge valves in the feed water line to the boilers.

Fig. 2 shows the feed-pipe arrangement to supply two plants and intended to bring the returns from the heating system in all the buildings to an open heater in No. 1 plant, using one of the feed pumps, connected as pumps Nos. 1 and 2 in Fig. 1, to feed the boilers of both plants, although No. 2 plant was 400 ft. distant. The pump was controlled by a pressure regulator connected on the line to plant No. 2 instead of one on each pump, and the feed was regulated by the valve in the feed line. Therefore, the pump had to be slowed down when the boilers in No. 1 plant had sufficient water. A relief valve *A* was put in the line at No. 2 plant to prevent overpressure on the pipe line. Any of the valves *B*, *C* and *D* on the line might be closed by accident, and if *C* and *D* were closed that would make the relief valve useless.

When the method of feeding plant No. 2 boilers from plant No. 1 had been abandoned, there was no shutoff valve on the line running to plant No. 2 from plant No. 1 except the valve *C*, which was left open to allow the relief valve *A* to be in service on the feed line to the boilers of No. 1 plant. One day someone in No. 2 plant opened the valve *B* on that feed line and flooded the boilers in No. 1 plant. After this happened, the valve *C* was closed, which cut the relief valve *A* out of service. On one occasion the locknut on the stem of the relief valve became loose and the pressure fluctuating in the pipe line caused the adjusting bolt to back out, leaving the relief valve open, and water was pumped from No. 2 plant into the pump suction pipe in No. 1 plant through to the open heater until the valve *D* was closed.

The relief valve *A* should have been connected between the valve *C* and the vertical pipe and the pressure gage just above it. This would leave the relief valve *A* in service on either line. As now placed, it is out of service and a continued source of trouble unless screwed down solid, so that it cannot open, as both the valves *C* and *D* leaked and either the boilers in the plant carrying the lowest pressure or the heater in No. 1 plant were constantly flooded. Therefore the relief valve is set and sealed tight shut, and any time the assistant forgets to open a discharge valve on the pump, he has the job of putting in a new gasket under the discharge chamber of the pump, as the pipe and fittings are all extra-heavy and withstand a very heavy pressure so the gasket is the first to go.

Had there been a check valve on the suction pipe to the pumps near the open heater, the water escaping back through the relief valve from No. 2 plant would not have flooded the heater. Though the idea of operation was a good one, the success was defeated by the use of a water-pressure regulator on the feed line and

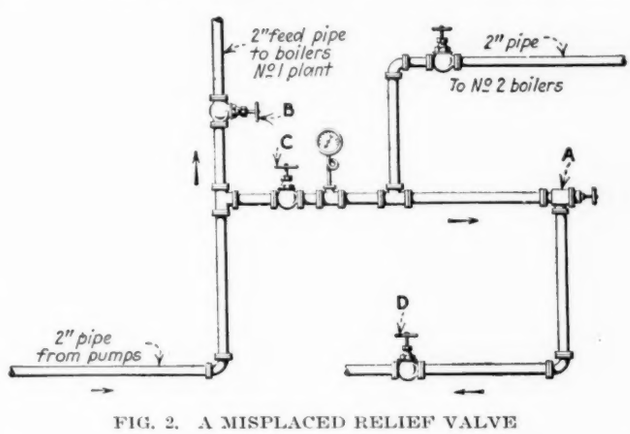


FIG. 2. A MISPLACED RELIEF VALVE

the misplacement of the stop valve *C* and the relief valve *A* in No. 1 plant, whereas a suitable pump governor should have been used.

The best way to detect leakage through the relief valve is to have the discharge flow into a funnel on a drain pipe, although this would allow the water to go to waste. A relief valve should be of the same size as the discharge pipe. A small valve will give a warning, but will not prevent the pressure from building up to a dangerous limit on sprinkler systems and pipe lines in case the pump should run away.

R. A. CULTRA.

Cambridge, Mass.

How One Engineer Cut Down Expenses

The average engineer will generally maintain that his plant is being operated as economically as possible. In the following instance I want to show what can be done in certain cases.

At the pumping station where I am employed, we have a 200-hp. 870-r.p.m. 2,300-volt three-phase slip-ring induction motor directly coupled to a 16-in. centrifugal pump operating under an 80-ft. head; also a 475-hp. 1,170-r.p.m. 2,300-volt three-phase slip-ring motor directly coupled to a 16-in. centrifugal pump operating under a 160-ft. head. As this is a booster station and the static head is 280 ft., the total head would be 360 and 440 ft. respectively, with the pumps in operation.

After a few trials it was found that a 410-ft. head was the maximum pressure that the discharge line would withstand, and this pressure was maintained by means of a bypass valve cut in directly between the intake and discharge headers. By slightly opening this valve, water would pass back from the discharge side to the intake side.

As the flow was rather irregular, it kept the operator busy holding the head at 410 ft. It was not advisable to change the pump design, as later the full capacity of the unit would be needed.

This method of regulation, although it worked, was very inefficient from an electrical point of view, as the motor, under these conditions, actually delivered 530 hp. and the pump was delivering from 250 to 475 water horsepower.

After considerable thinking I determined to reduce the speed of the motor by means of a water rheostat cut in on the secondary circuit. I did not wish to purchase anything, as the idea was to save money. With this in mind I gravitated to the "junk" pile and found a wooden tank about 5 ft. long, 4 ft. deep and 2 ft. wide. I also discovered an assortment of iron pipe, ½ to 3 in. in diameter and in random lengths. I was, however, compelled to purchase 36 ft. of cable for the main leads to connect the slip rings to the rheostat. The sketch shows the outfit. For connections between the pipe electrodes I stripped the insulation from a few damaged motor coils. This gave me a supply of ⅛ x ¾-in. copper strips.

As I had no data to work on, I was compelled to work out all the details, such as area of pipes, total amperage in secondary circuit at reduced speed and voltage across phases. The last was important, as I had to figure on the proper space between the electrodes. I calculated on an average speed of 1,000 r.p.m., and a little testing showed that the voltage would be 110, or less if higher speed were desired.

From data I had collected on other tests, I knew that with a current density of 1 ampere per square inch, using pure water as a solution, I would get a drop of about 2,000 volts per inch gap.

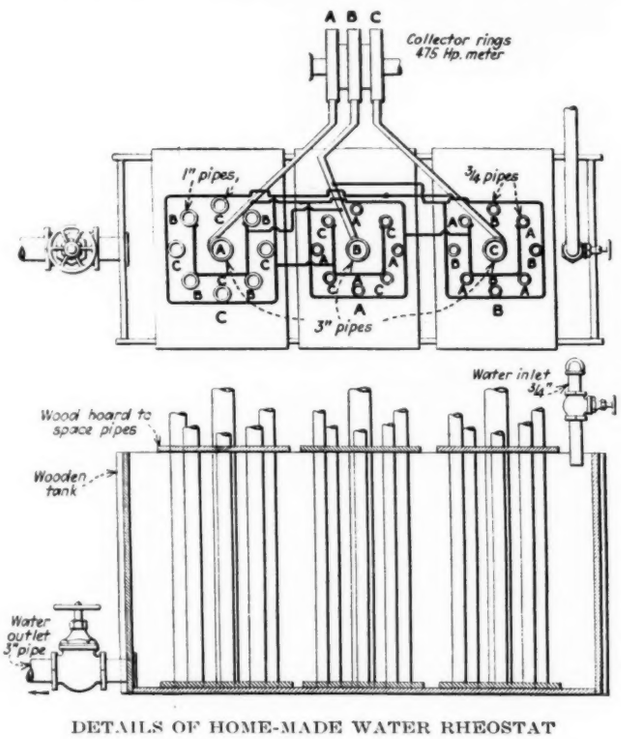
As I did not wish to have less than 1-in. gap, on account of the high voltage at starting (namely, 629), I chose this figure. Calculating on 110 volts and 200 amperes called for about 1 ampere to 9 square inches.

This I obtained by means of pipe electrodes, divided as follows: Three 3-in. pipes 48 in. in the solution gave an area of 1,584 sq.in.; sixteen ¾-in. pipes gave an area of 2,304 sq.in., and eight 1-in. pipes an area of 1,600 sq.in., making a total area of 5,488 sq.in., or 1,829 sq.in. per phase. This was equalized by mounting the 8-in. pipes upright in the tank and surrounding them with eight smaller ones spaced one-inch gap. This number also gave the required gap between the 3-in. and the other pipes.

The sketch shows the connections, and when in operation the three phases balanced exactly.

When I started up, I found that I had to add a small amount of salt, as it required about 1,010 r.p.m. to get a 410-ft. head on the pump. By adding more salt I could bring the speed up to 1,150 r.p.m., but 20 revolutions below full speed.

I was surprised to find that the power factor, normally 90 per cent lag, stood at 91 per cent under the new condition. After the unit had been in operation four hours, the water approached the boiling point and the motor had a tendency to speed up. This was overcome by draining out hot water and adding cold. This rheostat was extremely sensitive and maintained a close balance between electrical and water horsepower, so that the unit as a whole was nearly self-regulating as regards pressure.



DETAILS OF HOME-MADE WATER RHEOSTAT

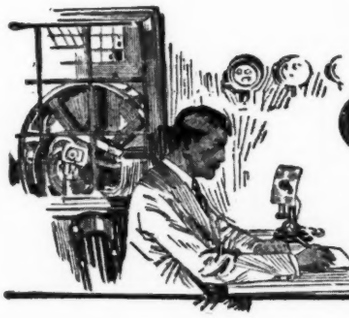
Following is a brief summary of the test, which lasted a week:

Normal Conditions	With Rheostat On
Speed, r.p.m., 1,170	1,000 to 1,100
Kilowatts, 400	250 to 350
Power factor, per cent	91
Gallons water pumped, both runs	Same
Kw.-hr. per 24 hrs. 9,000, average	7,500
Net saving per day, 24 hours, 1,500 Kw-hrs.	

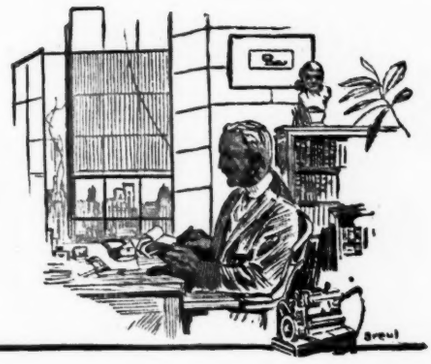
This makes a nice showing at the end of the month, as it just pays the operating crew's salaries.

The first day's saving paid for the cable, and as the operators themselves installed the equipment and as the balance of it was scrap, there was no other expense. This outfit was installed merely to work out the theory, and results show that the theory was correct.

Pittsburgh, Pa. M. A. ANDERSON.



INQUIRIES OF GENERAL INTEREST

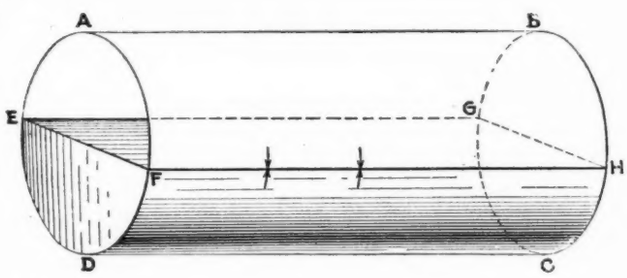


Density of Water at Stated Temperature and Pressure—What is the weight of a cubic foot of water at the temperature of 200 deg. F. when under a pressure of 150 lb. per sq.in. above the pressure of the atmosphere? B. E. L.

The weight of a cubic foot of water under atmospheric pressure and at the temperature of 200 deg. F. is 60.124 lb. At that temperature the compressibility of water is about 0.00004 of its volume per atmosphere of pressure, and for 150 lb. per sq.in. or about 10 atmospheres above atmospheric pressure, a cubic foot would weigh $60.124 \div (1 - 0.00004)^{10} = 60.148$ lb., or only about 0.04 of 1 per cent heavier than at atmospheric pressure.

Force Tending to Rupture a Longitudinal Joint—A cylindrical boiler, 4 ft. 3 in. in diameter by 12 ft. long, carries a pressure of 80 lb. per sq.in. What is the total force tending to rupture the boiler along a longitudinal joint and what is the stress per inch length of joint? R. S. H.

Referring to the sketch, if *ABCD* is a hollow cylindrical vessel subjected to internal pressure, then neglecting any assistance rendered by the heads, the upper half, *EAFHBG*, would be held to the lower half by the tensile strength of the material all along and at right angles to the lines *EG* and *FH*, like the resistance of a hoop acting in direction indicated by the arrows. The tensile stress caused by the internal pressure tending to separate one-half of the cylinder from the other half along *EG* and *FH*, would be the same whether that other half is filled with a gas, vapor, liquid or solid, or whether the part *EDFHCG* is a rigid solid of any form to which the hollow half-cylinder *EAFHBG* is attached.



If the lower half is a rigid solid, then with the upper half subjected to internal pressure, as action would be equal to reaction, the total pressure tending to raise the upper half would be equal to the total downward pressure on the face *EGHF*; and neglecting resistance by the heads this total force would have to be resisted one-half by the material of the shell along *EG* and one-half by the material along *FH*. Therefore, the total stress tending to rupture the cylinder along a joint *FG* or *FH* is the pressure per sq.in. multiplied by one-half of the area of *EGHF* in square inches, or the product of pressure by radius by length. For each inch-length of longitudinal joint the stress would be pressure per sq.in. $\times$ ½ diameter $\times$ 1, or simply pressure per sq.in. $\times$ radius.

Hence, if the diameter of the boiler is 4 ft., 3 in. = 51 in. diameter or radius = 25½ in., and the length is 12 ft. or 144 in., neglecting any resistance offered by the heads (as usual in boiler computations), the total force tending to rupture the shell along a longitudinal joint would be $80 \times 25\frac{1}{2} \times 144 = 293{,}760$ lb.; and the force per inch-length of longitudinal joint would be $80 \times 25\frac{1}{2} \times 1 = 2{,}040$ lb.

Formula for Drop of Pressure in Steam Pipes—What is the formula for the drop of pressure of steam flowing through a pipe? W. D. T.

The general formula most commonly employed for rate of flow of steam in pipes is

$$W = 87 \sqrt{\frac{Density \times Pressure\ drop \times d^5}{L\left(1 + \frac{3.6}{d}\right)}}$$

in which

W = Weight of steam flowing per min. pounds;
Density = Weight per cubic foot of steam at the average pressure;
Pressure drop = Drop of pressure per square in. for the length of pipe under consideration;
d = Diameter of pipe in inches;
L = Length of pipe in feet.

Squaring both sides of the equation gives

$$W^2 = 87^2 \times \frac{Density \times drop \times d^5}{L\left(1 + \frac{3.6}{d}\right)}$$

from which

$$Drop = \frac{W^2 \times L\left(1 + \frac{3.6}{d}\right)}{87^2 \times density \times d^5}$$

Size for Duplex Feed Pump—What size of duplex boiler-feed pump would be suitable for return-tubular boilers whose nominal evaporative capacity is 9,000 lb. of water per hour? P. T.

To meet emergencies of low water and for forcing boilers, it is usual to supply a feed-pump capacity of twice the normal evaporative capacity. Hence, for a normal requirement of 9,000 lb. of water per hour the pump, when operated at maximum speed, should be capable of handling 18,000 lb. of water per hour, or $\frac{18{,}000}{8.33 \times 60} = 36$ gal. per min.

Allowing 10 per cent for slip of the pump and displacement of the piston rod, the displacement required of each water piston would be $36 \times 1.10 \div 2 = 19.8$ gal. or $19.8 \times 231 = 4{,}573.8$ cu.in. per min. and allowing a piston speed of 60 ft., or 720 in., per min., the required piston area would be $4{,}573.8 \div 720 = 6.3525$ sq.in., or a diameter of $\sqrt{\frac{6.3525}{0.7854}} = 2.84$ in.

The usual commercial size of duplex pump next larger is 5¼ in. $\times$ 3½ in. $\times$ 5 in.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Interpretations of the A.S.M.E. Boiler Code

REQUESTS for interpretations of the Boiler Code are acted upon by the Boiler Committee, their formulated replies being submitted to the Council of the American Society of Mechanical Engineers. The inquiries and replies are published from time to time in *Power*, with such explanatory comments and illustrations as seem advisable for a clear understanding of the interpretations on the part of engineers in general. The last group of interpretations published in *Power* was in the issue of May 17, 1921.

Case No. 335—Inquiry: (a) Are manhole frames when of the flanged type considered reinforcing rings and so necessitate their thickness to be at least that of the shell plate, or are they not so considered, so that they can have a thickness less than the shell plate provided their strength meets the requirements of Par. 260?

(b) As no method of calculating the strength of flanged manhole frames is given in the Code, would the following method be acceptable? From twice the median line, ABCDE, in Fig. 1, subtract twice the rivet-hole diameter and multiply the result by the thickness of the frame and this by the tensile strength.

Reply: (a) The thickness of the shell-plate referred to in Par. 259 and 260 is that required by Par. 180 and the thickness and strength of manhole frames and reinforcing rings shall conform to those required for such a shell-plate thickness. When the shell-plate is made of greater thickness, such excess thickness shall be given no consideration in the calculations in these paragraphs.

(b) It is the opinion of the committee that safe results will be obtained by using as a reinforcement to the ring the flange height h up to three times the flange thickness. (See Fig. 1.)

Par. 259 provides that the material of the ring shall be at least as thick as the shell plate. Par. 180 gives the rule for the thickness of the boiler shell. Fig. 1 represents a manhole reinforcing ring placed on a boiler drum. The section is taken parallel with the length of the drum. It is evident that the pressure tends to split the shell lengthwise along the section shown. The cutout for the manhole reduces the strength of the section by the tensile strength of the areas cut out, consisting of the two rivet holes and the dotted area *abcd*. Par. 260 provides that the strength of the manhole reinforcing ring must be equal to the tensile strength of the cutout area just mentioned, but does not state how to compute the strength of the ring. Section (b) of the inquiry would replace the net area

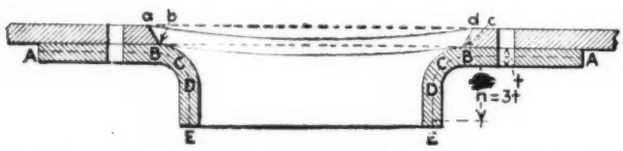


FIG. 1. (CASE NO. 335) MANHOLE REINFORCING RING

cut out along the section by exactly the same net cross-sectional area of ring. Section (b) of the reply permits this with the proviso that the part (if any) of the flanged portion projecting *beyond* a height h equal to $3t$ shall not be used in figuring the net cross-sectional area of the ring.

Case No. 347—Inquiry: Does the requirement of Par. 195 of the Boiler Code for an increase of ½ in. in thickness of a dished head fitted with a manhole opening, apply only to concave heads or to both concave and convex heads?

Reply: It was the intent of the committee that the increase in thickness of ½ in. for dished heads with manhole openings shall apply in all cases whether the heads are concave or convex.

Par. 195, under the heading "Concave Heads," provides that when a dished head has a manhole opening, the plate thickness shall be at least ½ in. more than required for dished heads without manholes.

Case No. 348—Inquiry: Would the attachment of a forged-steel manhole neck to a convex head, as shown in Fig. 2, be considered the equivalent of a flanged opening supported by an attached flue and thus be exempted from the requirements for the ½-in. increase in thickness specified in Par. 195 of the Boiler Code?

Reply: The manhole neck shown in Fig. 2 is not supported in the sense that it assists the convex head in withstanding the stress due to the steam pressure, and accordingly it is the opinion of the committee that it cannot be considered that the head there shown is "supported by an

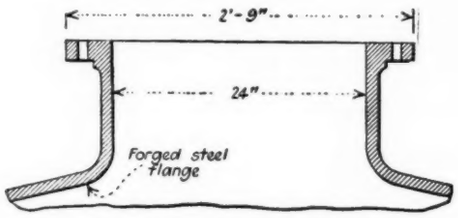


FIG. 2. (CASE NO. 348) DISHED HEAD WITH FORGED STEEL MANHOLE NECK

attached flue," and therefore it cannot be exempted from the requirements for the ½-in. increase in thickness.

Par. 195 (as an exception to the rule given under Case 347) provides that "where a dished head has a flanged opening supported by an attached flue, the increase of ½ in. in thickness is not required."

Case No. 349—Inquiry: Is it permissible, under the requirements of the Boiler Code, in fitting dished heads to the ends of air cylinders or steam drums, to so form the convex head that its flanged edges fit over the outside of the end of the shell, as shown at the right in Fig. 3, instead of within the shell (as shown at the left in Fig. 3), as is usual,

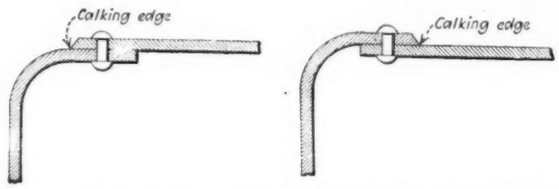


FIG. 3. (CASE NO. 349) APPROVED FORMS OF JOINTS FOR DISHED HEADS IN CYLINDRICAL SHELLS

in order that a tighter joint may be obtained by calking the edges of the flange to the outer surface of the shell?

Reply: It is the opinion of the committee that the form of construction proposed is entirely in accord with the requirements of the Boiler Code.

Case No. 350—Inquiry: Is it permissible, under the rules of the Boiler Code, in fitting different courses of the shell of a boiler at the ends of butt-strapped joints, to weld them together autogenously, in order to avoid the use of plugs or "dutchmen" to render the joints tight?

Reply: It is the opinion of the committee that if the stress upon the joint is fully carried by the butt straps, the use of welding to render the ends of the joints tight is fully in accord with the requirements of Par. 186 of the Code.

Par. 186 permits the use of autogenous welding in cases where the strain is carried by other construction which conforms to the requirements of the Code and where the safety of the structure is not dependent on the strength of the weld.

Case No. 351—Inquiry: Is it necessary, under Par. 2 of the Boiler Code, that welded or seamless circular furnaces or flues in boilers up to 18 in. in diameter, as specified in Par. 241, must conform to the requirements for firebox-plate material when exposed to the products of combustion?

Reply: It is not necessary that welded or seamless circular furnaces or flues up to 18 in. in diameter meet the specifications for boiler-plate material. It is the opinion of the committee that such boiler parts should be constructed from material fulfilling the requirements for lap-welded and seamless boiler tubes given in Par. 165 of the Boiler Code.

Par. 2 reads "Steel plates for any part of a boiler when exposed to the fire or products of combustion, and under pressure, shall be of firebox quality as designated in the Specifications for Boiler

Plate Steel." Par. 241 gives formulas for determining maximum allowable pressure for seamless or welded flues from 5 in. to 18 in. in diameter. The formulas given are based on dimensions only and no mention is made of material to be used. Par. 165 says that steel used for lap-welded or seamless tubes, shall have chemical analysis as follows:

	Low	High	
Carbon	0.08	0.18	per cent
Manganese	0.30	0.60	"
Phosphorus	..	0.04	"
Sulphur	..	0.045	"

Case No. 352—Inquiry: Is it not permissible to construe boilers of the locomotive, economic or other portable type as coming under the classification of traction or portable boilers, as regards the attachment of lugs or brackets for which Par. 325 of the Boiler Code permits the use of studs with pipe threads? It is found impossible to properly rivet the lugs on certain designs of locomotive-type boilers where the lugs are to be located near the bottom of the water-leg of the firebox.

Reply: It is the opinion of the committee that where boilers of the portable type are to be fitted with lugs or brackets, the practice specified in the last sentence of Par. 325, using studs, is permissible.

Par. 325 permits the use of studs with pipe threads for attaching lugs or brackets to traction or portable boilers.

Case No. 353—Inquiry: Is it permissible, under the requirements of Par. 218 of the Boiler Code, to use stay tubes in place of through stays for supporting the surfaces around the manhole in the heads of horizontal return-tubular boilers?

Reply: Stay tubes are not permissible for supporting the surfaces around the manhole in the heads of horizontal return-tubular boilers.

Par. 218 specifies the use of through stays around a manhole in a horizontal return-tubular boiler when the manhole is in the portion of the head below the tubes.

Case No. 354—Inquiry: What are the requirements of the Heating Boiler Section of the Code, relative to the staying of flat surfaces of steel heating boilers designed to operate at a pressure not to exceed 15 lb. per sq. in?

Reply: Par. 372 of the Code specifies a shop test of 60 lb. per sq. in. hydrostatic pressure shall be applied to steel or cast iron boilers used exclusively for low pressure steam heating. It is the opinion of the committee that in staybolting a boiler of this sort, the stresses in the material should not exceed those allowable in power plant practice, which would necessitate computing the staybolts and their spacing for a working pressure of at least 40 lb. per sq. in., or two-thirds of the test pressure.

Case No. 356—Inquiry: Is a locomotive-type boiler constructed as shown in the prints and described safer under the Boiler Code Rules than other forms of similar boilers?

Reply: The Boiler Code Committee does not express opinions upon the relative merits of different designs of boilers. This is in accordance with the Constitution of the Society, C56 of which reads as follows:

> "The Society shall not endorse any commercial enterprise. It shall not allow its imprint or name to be used in any commercial work or business."

An interpretation of the Boiler Code is a proper action of the Boiler Code Committee and will always be given upon request.

Instruction Offered Marine Engineers

Holders of federal licenses as marine engineers will be interested to learn that the government is offering them free courses designed to train men as turbine engineers. The instruction is comprehensive, covering not only the ordinary work on boilers, valve gears, oil burners, refrigeration, etc., but also a study of the different types of turbines and their adjustment and operation. A certain necessary amount of work is given on thermo-dynamics and trigonometry.

Although it is understood that these courses are being paid for by the government, they are being conducted at the present time by four established educational institutions in different parts of the country. Every man that holds a federal ticket is eligible, and thus has an opportunity to secure, without cost, instruction that may be of great value to him.

Anyone that cares to learn more about these courses should write to one of the four following institutions.

The places where courses are given and the men to write to are as follows: Cambridge, Mass., Massachusetts Institute of Technology, Harrington Pike, 20 Atlantic Ave., Boston, Mass.; Brooklyn, N. Y., Polytechnic Institute, Prof. E. F. Church, Jr.; New Orleans, La., Tulane University, Prof. James M. Roberts; Seattle, Wash., University of Washington, Professor E. O. Eastwood.

Hoover Favors New Marine Boiler Regulations

Those who have to do with marine boilers will be interested in the letter addressed to Secretary Hoover by F. W. Dean, secretary of Wheelock, Dean & Bogue, Inc. (power-equipment specialists, 141 Milk St., Boston, Mass.), and in Mr. Hoover's reply. The letters follow:

Hon. Herbert Hoover, July 21, 1921.
Secretary of Commerce,
Washington, D.C.
Dear Sir:

As a mechanical engineer, a member of the American Society of Mechanical Engineers and of the Boiler Code Committee of that society, and also a former member of the boiler department of the Emergency Fleet Corporation, I wish to call your attention to the antiquity and inadequacy of the "General Rules and Regulations Prescribed by the Board of Supervising Inspectors" with reference to the construction of marine boilers.

For many years it has been the ardent wish of all persons concerned with marine boilers that the rules should be modernized. Strong but fruitless efforts have been made to bring this about.

The association for the promotion of the adoption of the boiler rules of the American Society of Mechanical Engineers has made efforts to have the A. S. M. E. rules adopted by the Department of Commerce with no better success.

The rule concerning riveted joints of boilers is such that nobody would think of following it and no marine classification society would permit boilers designed in accordance with it to be used.

As you are an engineer, perhaps an appeal made to you may serve to overcome the inertia that seems to surround all efforts made to have the Rules changed.

Very respectfully yours,
F. W. DEAN.

Mr. F. W. Dean, July 26, 1921.
Wheelock, Dean & Bogue, Inc.,
141 Milk St.,
Boston, Mass.
Dear Mr. Dean:

1. The Department is in receipt of your letter of the 21st instant, calling attention to what you describe as the antiquity and inadequacy of the "General Rules and Regulations, Prescribed by the Board of Supervising Inspectors," with reference to the construction of marine boilers, and stating that for many years it has been the ardent wish of all persons concerned with marine boilers that the rules should be modernized, and that strong but fruitless efforts have been made to bring this about.

2. In reply, I beg to say that the Board of Supervising Inspectors of Steam Vessels realizes the situation and the Supervising Inspector General of Steam Vessels has recommended to the Department that Sections 4433 and 4418, R.S., be amended, and if those sections are amended as proposed by the Supervising Inspector General, then the Board of Supervising Inspectors would have authority to make General Rules and Regulations, so far as boiler construction is concerned, that would make the practice of the Steamboat-Inspection Service absolutely modern and put it abreast of the very best practice of all other societies.

3. You will find inclosed herewith a copy of the Annual Report of the Supervising Inspector General for the fiscal year ended June 30, 1920, your attention being particularly invited to the paragraph "Boiler Pressure," commencing upon page 19.

4. In conclusion, it may be stated that a bill has already been introduced looking to the amendment of the sections in question, and just as soon as Congress takes action and gives the board the proper legislative authority, the board will do its part.

Faithfully yours,
HERBERT HOOVER,
Secretary of Commerce.

Washington News

Henry Ford's Muscle Shoals Offer Favorably Considered—Coal Exchange Being Discussed—Statement on Trade Associations To Be Issued

By Paul Wooton
Washington Correspondent

Since the defeat of the appropriation to continue work on the Wilson dam, there has been a feeling on the part of some of the friends of that project that the Muscle Shoals development was enmeshed hopelessly in politics and misunderstandings. There is a growing impression, however, that Henry Ford's offer is a way out. While several propositions were submitted in response to the request of the chief of engineers, there was but one practical proposal—that of Mr. Ford. The others were indefinite and unaccompanied by any evidence that the persons submitting them commanded the financial resources necessary to develop them.

J. B. Duke, the president of the Southern Power Co., is understood to have expressed the opinion that the government cannot complete the Wilson dam and the hydro-electric plant and obtain a reasonable return on the investment. His opinion, which is subscribed to by all the southeastern hydro-electric companies except the Alabama Power Co., is understood to have been based on a report made by W. S. Lee, the chief engineer of the Southern Power Co.

The Alabama Power Co. is not in a position to submit a bid at this time. Thomas W. Martin, the president of the company, in reply to an inquiry by General Beach, the chief of engineers, has explained the position of his company in a detailed statement, which points out the obstacles in the way of making a proposition to the government at this time.

Objections to the Government Plan

The statement calls attention to Section 124 of the National Defense Act, of June 3, 1916, under which the Muscle Shoals dam and power plant are being constructed, and particularly to the following clause: "The plant or plants provided for under this act shall be constructed and operated solely by the government, and not in conjunction with any other industry or enterprise carried on by private capital." This provision, it is stated, casts some doubt on the authority of any agencies of the government to deal with the project as contemplated without further legislation.

Another objection given is that the company "Is not advised as to the extent to which the government is disposed to consider a portion of the investment as being due to war emergency; or what portion may properly represent its power supply for nitrate purposes, in addition to which it is assumed that a portion will be charged to the improvement of navigation of the Tennessee River." Thus it is not certain whether or not the power could be sold cheaply enough.

A third consideration advanced is that the company is in duty bound to supply power adequate to meet the constantly increasing demand, that it must make plans for necessary increases of capacity far ahead and that it would not be justified in depending for these increases upon the Muscle Shoals project, in view of the many difficulties involved and the uncertainty of Congressional action.

The company is of the opinion, however, that "If the above difficulties and uncertainties can in any manner be cleared up, and excessive costs avoided by fair charges to war emergencies, power for nitrate purposes, and improved navigation, the development can go forward and be completed with the view of the sale and distribution of a sufficient volume of power therefrom by this company and other companies engaged in public service in the territory adjacent to this development to enable the United States to derive a reasonable return upon such part of the investment as may be properly allocated to the power feature of the project."

The statement closes with an expression of the company's desire "to co-operate in every way desired by the United States in working out the matter."

Considerable criticism is reaching Washington as a result of the action of the Secretary of War in making public the Ford proposal. This gives an unfair advantage to other bidders, it is declared, and is contrary to the long established policy of the War Department.

There can be no doubting of the widespread and growing public demand that the Ford offer be accepted unless some one else is willing to submit a better proposition at once. This is evidenced by the large number of letters that are being received from all sections of the country by Senators and Representatives. The publicity the matter has received has also had the effect of arousing new demands that the government itself undertake the work; Senator Underwood continues to insist that the operation of the project by the government is the only way in which the public will receive the maximum benefit from this natural resource.

Discussion of the Coal Exchange

The expected discussion on the floor of the Senate of the possibilities of a coal exchange as a stabilizing element in the coal industry did not materialize, owing to the fact that Senator Dial's amendment to the grain futures bill was unexpectedly withdrawn. The withdrawal of the Dial amendment means that the discussion will be transferred to a sub-committee of the Committee on Agriculture.

Senator Ransdell's public statement that the coal exchange is being looked to as a stabilizing factor in the coal industry brought to light the fact that the matter has been under quiet discussion in government circles for the last several weeks. The idea has received stimulation in the success of the Sewell's Point Coal Exchange. It has been learned also that the American Wholesale Coal Association has made a formal proposal to assist the Department of Commerce and the Bureau of Mines in the study of the matter and that the tender of assistance has been accepted in each case.

It is admitted that the principal difficulty to be surmounted is the fixing of the grades of coal. The matter of sampling and analysis is not regarded as an obstacle, as it is known definitely that this can be done promptly and with sufficient accuracy to meet the requirements. At present, the grades of coal are hardly deserving of the name. Such terms as steam coal, domestic coal, lump and screenings may mean nearly anything. It is recognized that no such generalities could be made if coal is to be dealt with on an exchange. It is recognized also that, in addition to such sampling and analyzing as may be done, practice and experience must be utilized to a large extent in such determinations.

In such a plan, the function of the Bureau of Mines, as interpreted by Bureau officials, would not be to classify, but to gather the facts on which the classification would be based. The industry itself would have to do the classifying.

Trade Associations Being Investigated

An official statement having to do with the activities of trade associations will be issued the latter part of August. A promise to this effect was made by Commerce Secretary Hoover after a conference on the subject between Mr. Hoover and members of his staff with the Attorney General and members of the Department of Justice staff. Pending the issuance of the statement, Mr. Hoover declines to comment. The Attorney General stated that there is a great number of trade associations that are of much benefit to business and that the activities of the great majority of these organizations are not being questioned. He said the Department of Justice simply is trying to find if there are not some cases in which illegal activities are being carried forward under the guise of trade associations.

The probabilities are that the official statement that is to be issued will not go very far toward illuminating the twilight zone covering a part of the field of some of the existing associations.

Coal Mining Conditions

After conferring with the Secretary of Labor on behalf of the Mine Workers of America, Walker J. James stated that bituminous coal miners are averaging only two days' work a week and for that reason could not consider a wage reduction. Mr. James stated that he had conferred with Secretary Davis on general conditions in the industry. He said also that the mine workers are more than willing to join with the government and the operators in an effort to start coal buying.

Commerce Department Publishing Useful Information

A circular letter from Herbert Hoover is at hand, introducing the "Survey of Current Business" for July 1, 1921. To quote from the letter: "The figures given represent, in a large measure, those data which the Secretary and executives of the various departments find necessary to have at hand for their own use and involves little expense to make them generally available. There has been a large demand that these figures be prepared for general use as others find them of great assistance. . . . It is planned to issue this publication as soon as possible after the 20th of each month, to show the figures for the preceding month."

The booklet is of generous proportions, being 9 x 11¼ in. in size and 55 pages long. Comprehensive data on the condition of various industries are summarized in forty tables, two for each kind of business, and are compared to pre-war values by the use of index numbers. A monthly average, which in most cases represents 1913, is taken as 100; the figures for the current month are then represented by a number that is in the same ratio to 100 as these figures are to the 1913 average. In this way, the true significance of the month-to-month variations can be more readily grasped. In most of the tables these figures are given for each month from the first of 1920, and in the previous years only the monthly average for the year is given. An excellent idea may thus be obtained of the business situation in any particular line by running down the columns of index numbers. In addition to the index numbers, however, the actual figures from which they are derived are in each case given in a separate table.

The table on "Fuel and Power" places the June, 1921, production of bituminous coal at 85 per cent of the 1913 average. Production of crude petroleum in June is given as 202 per cent of the 1913 figure, while the imports of that product are placed at 688 per cent.

While the bulletin contains no statement of price, it may undoubtedly be secured at a small charge from the government printing office at Washington.

Additional N. E. L. A. Committee Chairmen Chosen

In addition to appointments of committee chairmen already announced, President Milan R. Bump of the National Electric Light Association has made the following appointments of chairmen of special national committees:

National counselor to the United States Chamber of Commerce, and national representative upon the National Industrial Conference Board, John W. Lieb, New York Edison Company, New York City; finance committee, Joseph B. McCall, the Philadelphia Electric Co., Philadelphia, Pa.; water power development committee, Franklin T. Griffith, Portland Railway, Light and Power Company, Portland, Ore.; electrical resources of the nation, W. S. Sloan, Brooklyn Edison Co., Inc., Brooklyn, N. Y.; lamp committee, Frank W. Smith, the United Electric Light & Power Co., New York City; wiring committee, R. S. Hale, the Edison Electric Illuminating Co. of Boston, Mass.; insurance committee, B. E. Wolff, Hodenpyl Hardy & Co., Inc., New York City; constitution and by-laws, W. C. L. Eglin, the Philadelphia Electric Co., Philadelphia, Pa.; Doherty and Billings prizes, A. S. Loizeaux, Consolidated Gas, Electric Lgiht & Power Co., Baltimore, Md.

The following have been appointed by President Bump as chairmen of general national committees: Accident prevention committee, Charles B. Scott, Bureau of Safety, Chicago, Ill.; company employees organizations committee, R. B. Grove, United Electric Light & Power Company, New York City; membership committee, Walter Neumuller, the New York Edison Company, New York City.

A woman's committee on public information, just announced by Chairman Martin J. Insull, will be headed by Miss S. M. Sheridan, of the Detroit Edison Co.

The New York City delegates to the coming N. A. S. E. convention at Evansville, Ind., have decided to travel to the event by the New York Central. The New England States delegation will join them at Albany.

New Publications

REPORT OF PRIME MOVERS COMMITTEE OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION, No. T 5-21 Published By The National Electric Light Association, 29 West 39th St., New York City. Paper; 8x11 in.; 360 pages. Price, to members, $3.50; to non-members, $7.

A thoroughgoing and masterly discussion of the problems arising in the operation of power-producing machinery, prepared by men who have to meet those problems in their every-day work and by manufacturers whose machinery is involved. The personnel of the committee, of which N. A. Carle is chairman, is a notable array of prominent consulting and operating engineers. Their report was prepared for the 44th Convention of the National Electric Light Association at Chicago, May 31st-June 3rd, and has now been reprinted to meet the demand that exhausted the first edition. It is an important contribution to current technical literature, but is, nevertheless, essentially practical, dealing with operation and maintenance problems rather than with abstruse theories.

A considerable part of the work is taken up with discussions by the various manufacturers of power-plant machinery, who write, of course, from their own particular viewpoint, but are nevertheless able to add materially to the fund of information given by the book.

While the price may seem high, considering the size of the book, it is cheap indeed for anyone having need for practical up-to-date data on the operation of power plants.

OIL FLOW IN PIPE LINES. By R. S. Danforth, Assoc. Member A. S. C. E. Published by King Knight Co., San Francisco, Cal. Paper, 11¾ x 9 in.; 12 pages. Price, $3.

Although it is something of a shock to find a twelve-page pamphlet priced at $3, it is not inconceivable that the man who must solve frequent problems relating to the flow of oil in pipes may find that the ten pages of charts contained are worth the price. There are seven charts covering the relation between pipe size, rate of flow, Saybolt viscosity, Baumé gravity and pressure drop per 1,000 ft. of pipe. There is also a series of viscosity conversion charts and two charts for oil-pump horsepower.

Personals

James Carnegie, Jr., is now engineer of power plants for the Kwang Tung Electric Supply Co., Ltd., Canton, China.

William M. White, chief engineer of the hydraulic department of the Allis-Chalmers Manufacturing Company, has left for a stay of several months in Japan.

J. F. McNutt has finished his work for the United States Indian Service and has taken a position as chief engineer with the Leaver Manufacturing Company, Oakland, Cal.

Raymond D. Sherman is now assistant electrical engineer with the Philadelphia Co. of Pittsburgh, having resigned as superintendent of the Connecticut River Power Company.

William Mead has retired after forty-one years of continuous service as chief engineer at Sing Sing Prison. His record is excelled by only one employee, former State detective James Jackson, who served forty-five years at the institution.

William J. Shriver, of the steam boiler and engine inspection department of the Fidelity & Casualty Co., was transferred recently from the Milwaukee office to the Chicago Office, and now has charge of inspection work in the Chicago territory.

Hugo Diemer has been appointed director of the new Industrial Management Division of LaSalle Extension University. This division is to deal with industrial management efficiency, modern foremanship and production methods, and personnel management.

Obituary

Francis Burke Allen, for over 48 years associated with the Hartford Steam Boiler Inspection and Insurance Co., died recently in his 81st year at his Hartford home. His good work in the Hartford Company had brought him up to the position of vice president, which he held at the time of his death.

John L. Cochrane, statistician for many years of the United States Bureau of Mines, died in Cleveland on Aug. 3. His death came suddenly following his gradual apparent recuperation from a paralytic stroke that occurred in January. He had been in the Federal service in Washington for about fourteen years, first with the Technologic Branch of the United States Geological Survey, and later with the Bureau of Mines, before which he had been engaged in newspaper work in various cities in Ohio. He was born in Dundee, Scotland, 49 years ago, and came to the United States when only eight years old.

Prof. Charles L. Weil, consulting engineer, died at his home in Port Huron recently. He was actively identified with the Diamond Crystal Salt Company as consulting engineer and maintained a consulting engineering office of his own in Port Huron. Prof. Weil was born in North Andover, Massachusetts, in 1865. His engineering education was secured in the Massachusetts Institute of Technology, from which he was graduated in 1888. After a short period as draftsman with the Worthington Pump Company he became instructor at Lehigh University, leaving there in 1893 to take charge of the Engineering Department of Michigan Agricultural College, where he remained for thirteen years. While there he designed and installed a complete new power plant for the college, which was a model of its kind at the time, and most of which is still giving satisfactory service, in spite of a period of usefulness long enough to relegate to the scrap-heap a less skilfully designed installation.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Aug. 9, 1921	Aug. 16, 1921
Pool 1,	New York	$3.15	$3.00@3.25
Pocahontas,	Columbus	2.90	2.75@3.25
Clearfield,	Boston	1.90	1.65@2.15
Somerset,	Boston	1.70	1.50@1.90
Pittsburgh,	Pittsburgh	2.10	2.00@2.15
Kanawha,	Columbus	2.15	2.00@2.20
Hocking,	Columbus	2.15	2.00@2.25
Pittsburgh No. 8	Cleveland	2.30	2.25@2.35
Franklin, Ill.,	Chicago	3.15	3.00@3.55
Central, Ill.,	Chicago	2.20	1.90@2.35
Ind. 4th Vein,	Chicago	3.10	2.90@3.25
Standard,	St. Louis	1.75	1.75
West Ky.,	Louisville	2.25	2.00@2.85
Big Seam,	Birmingham	2.15	2.00@2.25
S. E. Ky.,	Louisville	2.30	2.25@2.40

New York—On Aug. 17, Port Arthur light oil, 22@25 deg. Baumé, 4¼c. per gal. 30@35 deg., 5¼c. per gal. f.o.b. Bayonne, N. J.

Chicago—Aug. 13, for 24@28 deg. Baumé, 40@45c. per bbl.; 32@34 deg. 1@1½c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Aug. 8, f.o.b. refinery; Pennslyvania, 36@40 deg., 3¼c. to 3½c. Oklahoma, 24@30 deg. 40c. per bbl., gas oil, 32@34 deg., 1⅛@1¼c. per gal., 36@38 deg. 1¼@1⅜c. 38@40 deg. 1⅜@1½c.

St. Louis—Aug 13, prices, f.o.b. cars, tank lots; 24@26 deg. Baumé, 35c. per bbl.; 26@28 deg., 35c.; 28@30 deg. 40c.; 32@34 deg. 1⅜c. per gal.

Philadelphia—On Aug. 15, 26@28 deg. Baumé, Oklahoma, 50c. per bbl.; 30@34 deg., Oklahoma (group 3) 75c. per bbl.; 16@20 deg. Seaboard, 3¼c. per gal.

Cincinnati—July 29, for 22@28 deg. Baumé, 3c. per gal.

Cleveland—July 29, for 22@28 deg. Baumé, 5c. per gal.

New Construction

PROPOSED WORK

Mass., Boston—The city received bids for a 4 story, 43 x 142 ft. hospital on Harrison Ave., from J. Bowin Co., 184 Dudley St., $313,000; F. G. Coburn, Old South Bldg., $316,375; J. Slotnik Co., 448 Bway., $319,984. Noted Aug. 2.

N. Y., New York—R. H. Macy & Co., 34th St. and Bway., will soon award the contract for an 8 story factory on 35th St. and 11th Ave. About $300,000. R. D. Kohn, 56 West 45th St., Archt. and Engr.

N. J., Atlantic City—Rankin, Kellogg & Crane, Archts., 1012 Walnut St., Phila., Pa., are preparing preliminary plans and will receive bids about Oct. 1 for a 13 story addition to Haddon Hall Hotel on North Carolina Ave. and Beach, for Leeds & Lippincott. About $2,000,000.

Md., Annapolis—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until Aug. 31 for a power house, ash bunker and extension to coal bunker, here. Spec. 4487.

D. C., Washington—The Dist. Comrs., Dist. Bldg., received bids for installing a heating system in the Psychopathic Branch of the Gallinger Hospital, from the Federal Heating Co., 310 13th St., N. W., $50,814; Globe Automatic Springer Co., 2035 Washington Ave., Phila., $53,000; Shevlin Engr. Co., 110 West 34th St., New York, $54,807

Va., Roanoke—The city, c/o J. A. Page, is having preliminary plans prepared for a 3 story high school. About $500,000. H. C. Richard, 2006 Green St., Phila., Pa., Archt.

W. Va., Logan—The Bd. Educ. has had plans prepared for a 120 x 140 ft. high school. About $300,000. R. M. Bates, 1st Natl. Bank Bldg., Huntington, Archt.

Fla., Miami—The Miami Water Co., 12th and Court Sts., plans to build new water mains and install additional pumping equipment to pipe water from Lake Okeechobee. About $300,000. Hazen, Whipple & Fuller, 30 East 42nd St., New York, Engrs. Noted April 5.

O., Akron—The Warranty Security Discount Co., 65 South High St., plans to build a 20 story, 60 x 70 ft. bank and office building on Main and Buchtel Sts. About $1,000,000. J. H. Graham Co., 8201 Cedar Ave., Cleveland, Archt.

O., Canton—The First Savings & Loan Co., and The Dollar Loan & Savings Co., c/o E. E. Mack, Dollar Loan & Savings Co., 312 Market St., S, have merged and plan to build a 5 story bank and office building on Court and Tuscarawas Sts., W. About $300,000.

O., Cleveland Heights (Warrensville P. O.)—The Bd. Educ., E. K. Bryan, Clk., Lee Rd., received lowest bid for the installation of a heating system in the proposed Taylor Rd. School, from Feldman Bros., Barret Ave. Total cost, about $500,000.

O., Dayton—The Bd. Educ., Steele High Bldg., received bids for the construction of a high school, from Drummond-Miller Co., 4500 Euclid Ave., Cleveland, $347,130; Danis-Hunt Constr. Co., 1st and Webb Sts., $358,353; D. W. McGrath & Son, New 1st Natl. Bank Bldg., Columbus, $368,000.

O., Elyria—The Bd. Educ. received bids for building two 2 story schools and a heating plant, from L. A. Burgett Co., Lorain, $345,251; J. Kaiser & Bros., $367,000; G. Kratt, Lorain, $370,000.

O., Struthers—The Bd. Educ. will receive bids until Aug. 29 for a 2 story high school, including a steam heating system. About $300,000. Miller & Son, 408 Dollar Bank Bldg., Youngstown, Archts.

Mich., Detroit—The Detroit Police Dept., J. Inches, Comr., Bates and Farmer Sts., will receive bids until Sept. 1 for a 9 story, 117 x 172 ft. police station and a 3 story, 99 x 168 ft. armory, on St. Antoine St., A. Kahn, 1000 Marquette Bldg., Archt. Noted Feb. 8.

Ill., Belleville—The Chief of Construction Service, Room 2242 Munitions Bldg., Wash., D. C., will receive bids until Sept. 15 for the construction of steel airship hangar, including boiler house, etc., at Scott Field, here.

Ill., Chicago—The Hadomac Constr. Co., 111 Washington St., is having revised plans prepared for a 5 story, 64 x 171 ft. factory and office building on 36th Pl. and State St. About $450,000. Private plans.

Ill., Chicago—The Memorial Masonic Temple Assn., G. E. Dewy, pres., 740 East 41st St., is having plans prepared for a 3 story, 150 x 150 ft. masonic temple on 49th St. and Drexel Blvd. About $550,000. S. C. Dyer, 38 South Dearborn St., Archt.

Ill., Chicago—The Prince Hall Masonic Temple Assn., T. N. Sellers, 5756 South State St., is having plans prepared for a 5 story, 100 x 161 ft. masonic temple on 56th and State Sts. About $800,000. F. L. Fry, 140 South Dearborn St., Archt. and Engr.

Ill., Chicago—M. J. Sturm, Archt., 116 South Michigan Ave., is receiving bids for a 4 story 95 x 145 ft. nurses' home on Sedgewick and Garfield Sts. for the Augustanna Hospital Assn., 2043 Cleveland Ave. About $300,000.

Ill., Chicago—E. Stern, 922 Gault Ave., is having plans prepared for a 2 story, 260 x 300 ft. store and theatre building at 1617-37 Belmont Ave. About $2,000,000. W. Ahlschlager, 65 East Huron St., Archt.

Ill., Oregon—The Illinois Northern Electric Co., c/o A. Wait, Supt., is receiving bids for a 1 story addition to its hydro-electric plant. About $30,000. Holland, Akerman & Holland, 106 East Liberty St., Ann Arbor, Mich., Engrs.

Ill., Quincy—Penkelman & Cony plan to build a 2 story, 80 x 160 ft. theatre and store building, including a steam heating system. About $750,000. J. Eberson, 64 East Van Buren St., Chicago, Archt.

Wis., Milwaukee—The U. S. Government, Bd. of Mgrs. of the Natl. Soldiers Home, Dayton, O., is having preliminary plans prepared for a 2 story service hospital on the Soldiers Home grounds. About $1,400,000. Scott & Mayer, 445 Milwaukee St., Archts.

Ia., Webster City—E. P. Prince, Secy. School Bd., will receive bids until Aug. 30 for a 3 story, 165 x 193 ft. high school, including a steam heating system. About $250,000.

Mo., St. Joseph—The Methodist Episcopal Hospital, c/o J. R. Harper, Supt., 2602 Monterey St., is having plans prepared for a 7 story, 120 x 165 ft. hospital, including a steam heating system, on 8th and Faraon Sts. About $1,000,000. Eckel & Aldrich, 1105 Corb Forsee Bldg., Archts.

Mo., St. Louis—The Southwestern Bell Telephone Co., Boatmans Bank, is having plans prepared for a 3 story, 108 x 140 ft. office building, including a steam heating system, on 16th and Chestnut Sts. About $600,000. E. D. Minis, Pres. I. R. Timlin, c/o owner, Archt.

Tex., Crowell—The city, c/o Mayor, plans to build a complete waterworks system, including a pumping plant, reservoir, mains, etc. About $71,450. L. Noland Crowell, Engr.

CONTRACTS AWARDED

Conn., Danbury—The Danbury Hospital, Locust Ave., nurses' home, has awarded the contract for a 4 story, 35 x 117 ft. and a 4 story, 40 x 125 ft. service building, on Locust Ave., to W. Egelhof, 101 Park Ave. About $300,000. A steam heating system will be installed.

N. Y., Buffalo—The Hotel Statler Co., Washington St., will build a 17 story, 84 x 130 x 279 x 292 x 348 ft. hotel on Delaware Ave., Niagara Sq., etc. About $5,500,000. G. B. Post, 101 Park Ave., New York City, Archt. and Engr. Work will be done by separate contracts.

N. Y., New York—The New York Telephone Co., 15 Dey St., has awarded the contract for altering and building a 6 story, 100 x 140 ft. addition to telephone exchange on Convent Ave. and 146th St., to I. S. Rossell, 1 Madison Ave. About $300,000.

O., Toledo—The Bd. Educ. has awarded the contract for a 3 story, 70 x 300 ft. school, to A. Bentley & Son, 201-31 Belmont Ave. About $500,000. A steam heating system will be installed.

Ill., Chicago—The Illinois Steel Co., 3426 East 89th St., will build a 3 story, 92 x 375 ft. power plant at 3400 East 87th St. About $350,000. Work will be done by day labor.

Ill., Chicago—The Lambert Tree Estate, 138 North La Salle St., has awarded the contract for a 1 story, 125 x 160 ft. ball room on Madison and Hamlin Sts., to L. Balin Constr. Co., 528 South Clark St. About $300,000.

Ill., Chicago—The Sewell Clapp Envelope Co., 23 Desplaines St., has awarded the contract for a 1 and 2 story printing shop on Belmont and Tripp Sts., to R. C. Weiboldt, 1534 West Van Buren St. About $250,000.

Ill., Joliet—The Bd. Educ., J. F. Sweet, Clk., Library Bldg., has awarded the contract for a 3 story, 228 x 240 ft. high school at 901 Van Buren St., to Simmons-Dick Co., Bloomington. About $750,000.

Ia., Clinton—The Jane Lamb Memorial Hospital has awarded the contract for a 4 story addition, to Haring Bros., 402 Wilson Blvd. About $400,000. A steam heating system will be installed.

Ia., Des Moines—The Bd. of Water Wks Trustees, C. S. Denman, Mgr., 1001 Locust St., has awarded the contract for a 1 story, 125 x 125 ft. pump and boiler house, with coal pits and bunkers, to A. H. Neumann & Co., 519 Hubbell Bldg., $173,829. Noted Aug. 9.

Ia., Hopkinton—The Hopkinton Electric Light and Power Co., W. A. Millroy, Pres., will build a 20 x 32 ft. addition to its power house. Work will be done by day labor. Contract for machinery awarded to A. Chalmers Co., Ford Bldg., Detroit, Mich. Total cost about $35,000.

Kan., Wichita—The Miller Amusement Co., L. M. Miller, Pres., has awarded the contract for a 3 story, 140 x 150 ft. theater and store building on 19th and Lawrence Sts., to Southerland Building and Contracting Co., Syndicate Trust Bldg., St. Louis, Mo. About $600,000.

Neb., Pawnee City—The city has awarded the contract for reconstructing the lighting plant and for installing new equipment to the Merkle Mchy. Co., 508 Interstate Bldg., Kansas City, Mo., $61,600. Noted May 23.

S. D., Brookings—The city has awarded the contract for furnishing equipment for the power plant as follows: engine to Murray Iron Wks., 880 Washington St., Burlington, Ia.; boilers and blowers to Babcock & Wilcox, 85 Liberty St., New York; generator, switchboard, etc., to the General Electric Co., River Rd., Schenectady, N. Y.; stokers to the Combustion Eng. Co., 38 South Dearborn St., Chicago, Ill. Noted June 7.

Mo., Kansas City—The Kansas City Light and Power Co., c/o A. E. Bettis, Engr., 1500 Grand Ave., has awarded the contract for a 60 x 90 ft. light and power plant on 61st and Forest Sts., to Fogel Constr. Co., Reliance Bldg. About $34,000.

Tex., College Station—The State has awarded the contract for 2 buildings at the State College to consist of agricultural building and engineering shops, to Wattinger Bros., Austin. Total cost, $400,000.

Ont., Saulte Ste. Marie—The city has awarded the contract for a sewer pump, to the Northern Foundry & Machine Co., Bay St., $13,650.